

**2007 ANNUAL COMPREHENSIVE REPORT
OF GROUND AND SURFACE WATER QUALITY
TRONOX SODA SPRINGS, IDAHO FACILITY**

October 18, 2007

Prepared by:



GLOBAL ENVIRONMENTAL TECHNOLOGIES L.L.C.



GLOBAL ENVIRONMENTAL TECHNOLOGIES L.L.C.

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TRONOX
P.O. Box 478
Soda Springs, Idaho 83276

Attn: Mr. Boyd Schvaneveldt
Plant Manager

**RE: TRANSMITTAL: REMEDIAL ACTION 2007 ANNUAL COMPREHENSIVE
REPORT OF GROUND AND SURFACE WATER QUALITY TRONOX SODA
SPRINGS, IDAHO FACILITY**

Dear Mr. Schvaneveldt:

Enclosed please find transmitted the Remedial Action 2007 Annual Comprehensive Report of Ground and Surface Water Quality for the TRONOX Soda Springs, Idaho Facility. This document consist of: 1) an evaluation of the most currently available (May 2007) ground water quality distribution at on- and off-site locations for selected parameters; 2) an evaluation of ground and surface water quality changes with time; 3) projected decay trends for selected COC and wells, and; 4) conclusions regarding the effects to ground water from remedial actions and reclamation efforts to date.

We appreciate the opportunity to work with you on this project. If you have any questions regarding this transmittal, please contact us.

Very truly yours,

Global Environmental Technologies, LLC

John S. Brown, P.G.
Principal/Owner

Attachments: Remedial Action 2007 Annual Comprehensive Report of Ground
and Surface Water Quality

xc:

John Hatfield (TRONOX)
Paul Gutwald (TRONOX)
Russ Jones (TRONOX)
Toni Ellington – (TRONOX)
Mark Ader — EPA Region X – (4 copies)
Doug Tanner — IDEQ Pocatello
Dean Nygard — IDEQ Boise

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1.0 INTRODUCTION

1.1 Ground Water Monitoring Program

Tronox (formerly Kerr-McGee Chemical LLC) monitors water levels and water quality in both on- and off-site wells and selected springs on a semiannual basis. Data reports are presented to the EPA and IDEQ on a semiannual basis. A validation report that included the Remedial Design/Remedial Action (RD/RA) database was issued to EPA on September 20, 2007 (GET, 2007). Therefore, the database is not included in this report, and the reader should refer to the data contained in the validation report in conjunction with this document. The RD/RA database contains all analytical data supplied by the laboratory following the completion of the Remedial Investigation/Feasibility Study (RI/FS) study, and was prepared at the request of Region 10 EPA on September 23, 1997.

Monitor wells were installed at strategic locations to monitor specific surface water impoundments, aquifer units, downgradient off-site locations, and the TRONOX facility as a whole. Locations of on- and off-site well placements and screen location depths are shown in Table 1-1. These data are also presented in previous technical memoranda and work plans (Dames & Moore, 1991 a, b and 1992).

Location of the TRONOX site and property owned by Tronox is shown on Figure 1-1. Locations of all TRONOX wells installed during the remedial investigation (RI) are shown on Figure 1-2. Figure 1-2 also presents measured water level elevations and ground water gradients in May 2007.

Thirteen of the 18 RI/FS wells are designated "shallow" wells with total depths of 45 to 73 feet. Four wells are designated "intermediate-depth" wells with total depths of 100 to 173 feet. One well (KM-19) is completed on-site to a total depth of 230 feet and designated a "deep" well.

The shallow wells are completed with 10 feet of well screen that is set in the uppermost-defined basalt flow or interflow zone. Shallow wells were completed within the first occurrence of ground water while drilling. On-site shallow wells include wells KM-1, KM-2, KM-3, KM-4, KM-5, KM-6, KM-7, KM-8, KM-9, and KM-13. Off-site shallow wells include KM-15, KM-16, and KM-17.

The intermediate-depth wells are completed with 20 feet of well screen that is set in a deeper basalt flow identified across the site through geophysical interpretation. On-site intermediate depth wells include KM-10, KM-11, and KM-12. The off-site intermediate-depth well is designated KM-18.

1.2 Remedial Action Completion

A complete discussion of the Remedial Action Completion activities is described in the Draft Remedial Action Completion Report Revision I (GET, 1999), and the Draft Remedial Action Completion Report for Calcine Capping, 2000 through 2001 (GET, 2003). Remedial Action for the TRONOX vanadium facility addressed the selected site remedy from the Record of Decision (ROD, September 1995) and subsequent amendment to the ROD (July 2000). The Remedial Action for the vanadium plant included:

- Elimination of uncontrolled liquid discharges from the site;
- Landfilling solids from the scrubber and S-X ponds at an on-site landfill;
- In-place capping of the wind-blown calcine, roaster reject, reject fertilizer, and active calcine tailings during 2000 and 2001;
- Semi-annual ground water monitoring to determine the effectiveness of source control, and;
- Establishment of institutional controls in affected off-site areas to prevent ingestion of ground water for as long as the ground water exceeds the risk-based concentrations (RBC).

1.2.1 Liquid Source Elimination

The ROD required TRONOX (formerly Kerr-McGee Chemical LLC) to implement Liquid Source Elimination (LSE) to eliminate the uncontrolled releases of process water to ground water. During 1993, the unlined magnesium ammonium phosphate (MAP) ponds were removed from service and covered. This action had an immediate effect on water quality in nearby well KM-5. Three larger unlined ponds at the facility were either eliminated or replaced to accomplish LSE between 1995 and 1997. These three ponds included the roaster scrubber pond, S-X raffinate pond, and the calcine pond. Elimination of these ponds also had an effect on ground water quality

1.2.1.1 Scrubber Pond

Wet scrubbers controlled air emissions from the roasters since the plant began operating in 1963. The solids collected in the scrubbers and in the discharge water were pumped to various scrubber water ponds. This management practice resulted in an uncontrolled release of the process water to ground water, and left the solids from the process impounded in each pond. The scrubber sediments from the former pond on the east side of the facility were impounded in the on-site landfill, constructed during 1997.

The wet scrubbers were replaced by a baghouse system on each roaster in 1997. The baghouse collected particulate emissions without the use of water. Solids collected in the baghouse were impounded with the calcine. The result of the installation of the baghouse system was the elimination of the scrubber pond. This allowed for the excavation and placement of the roaster scrubber solids in the landfill and the closure and reclamation of the roaster scrubber pond.

The vanadium plant and supporting baghouse facilities were dismantled between October 2001 and February 2002. The footprint of the vanadium plant was covered

with limestone fines and recontoured to provide positive drainage away from the site of the former facility.

1.2.1.2 S-X Pond

TRONOX constructed double-lined ponds in 1995 and 1997 to contain the raffinate stream. The 5-acre ponds were reclaimed in 2004. Use of the unlined S-X pond was discontinued by 1996 and the sediment was pushed into a pile when the bottom was dry. The S-X pond sediments were impounded in the on-site constructed landfill in 1997.

1.2.1.3 Calcine Pond

Historically, calcine was deposited in the impoundment area by mixing the solids from the vanadium leaching process with water and pumping the slurry to the calcine impoundment. The water used in this operation infiltrated through unlined calcine ponds. TRONOX installed a mechanical dewatering system to separate the water and the calcine in 1997, eliminating the pond. No calcine was produced following closure of the plant in 1999 and the calcine impoundment site was capped with synthetic liner in 2001.

1.3 LSE Completion

TRONOX excavated and transported S-X and scrubber pond sludge to an engineered landfill constructed during September 1997. The S-X pond was taken out of service during 1996. During November 1996, the S-X pond sediments and underlying soils were scraped to the south end of the pond and covered with plastic. This allowed an extended period for the S-X solids to dry and consolidate. The scrubber pond came out of service in April 1997 and was drained prior to sediment thickness investigation.

The scrubber solids were worked into windrows and piles in the scrubber pond basin to accelerate drying. Prior to compaction in the landfill, the wastes were mixed at a ratio of 3:1 scrubber to S-X solids to achieve optimum moisture for compaction. During the last week of September 1997, the Idaho Department of Environmental Quality (IDEQ) inspected the pond basins and determined that all of the pond solids had been removed from the native soils lining the pond basins. Several feet of clean native soil were placed in the pond basins to support growth of a vegetative cover. The overall site slopes were graded and sloped to enhance runoff away from the preexisting pond locations.

Pond reclamation activities occurred during the last week of September and during the first week of October 1997. Following removal of sediment materials from the pond basins and approval of closure from the IDEQ, completeness of sediment removal from pond basins was documented with photographs.

1.4 Ground Water COC

The six contaminants of concern (COC) identified in the Risk Assessment (EPA, 1993) include arsenic, manganese, molybdenum, tributyl phosphate, total petroleum hydrocarbons, and vanadium. Table 1-2 presents a range of concentrations for COC at the POC wells, showing both the largest and the most recent (May 2007) concentrations.

2.0 SUMMARY OF SITE HYDROGEOLOGY

2.1 Site Hydrogeology

Ground water beneath and downgradient from the TRONOX site exists within the basalt sequences, the basalt interflow zones, and within limited areas of the alluvium. Ground water also exists within the Tertiary Salt Lake Formation that underlies the basalt. All of the on-site and off-site monitor wells installed as part of the TRONOX RI/FS are completed at various depths within the basalts, as shown in Table 1-1. Although ground water occurs in the Salt Lake Formation and within a limited area of the alluvium on-site, the basalts are considered the principal aquifer beneath the TRONOX site.

The hydrogeologic properties of the basalts and interflow zones were characterized for the TRONOX RI/FS, using:

- Geologic, geophysical, hydraulic head, hydraulic gradient, and hydraulic conductivity parameters from the installed wells;
- Hydraulic response data observed in the monitor wells, and;
- Observation and testing data from 14 on-site monitor wells, 4 off-site monitor wells and 5 on-site coreholes.

2.1.1 The Salt Lake Formation

The Tertiary Salt Lake Formation is comprised of tuffaceous sandstones, conglomerates and limestones that yield small amounts of ground water for domestic and stock purposes, and are unpredictable as a water-supply source. The Salt Lake Formation is not considered part of the shallow ground water system. The Salt Lake Formation was cored on-site in corehole CH-3 from 231 to 250 feet (total depth of corehole CH-3) and was found to consist of fractured quartzite, sandstone, and clay with a packer test hydraulic conductivity of 0.77 ft/day. This is within, but at the low end of the range of

packer-test hydraulic conductivities estimated for the deeper part of the overlying basalt sequence. No wells at the TRONOX site were completed within this formation.

2.1.2 Alluvium

Seismic refraction studies performed as part of the RI indicated that alluvium is thickest and extends to the greatest depth on the eastern side of the plant facility. Based on geologic data from well KM-2, a small area of thin saturated alluvium overlies the basalt in the eastern part of the TRONOX facility where the elevation of the basalt/alluvium contact falls below the elevation of the water table. Well KM-2 is screened across the basalt/alluvium contact. The area of saturated alluvium appears to be limited near the east side of the facility, extending a short distance to the north and south of the capped calcine tailings. The alluvium has not been noted to contain ground water at other locations on the TRONOX site.

2.1.3 Basalt Aquifer

The basalts and interflow zones of the mid-Pleistocene Blackfoot Lava Field comprise the principal aquifer beneath the TRONOX site. All of the on-site TRONOX monitor wells, with the exception of well KM-2, are screened exclusively within these basalts and interflow zones. The basalt sequence at the TRONOX site, described in the RI is comprised of five identifiable basalt flows (Basalts Nos. Qb₁ through Qb₅) and associated interflow zones (Interflow Zones Nos. I₁ through I₄). Two younger basalts (Qb_{5a} and Qb_{5b}) and associated interflows were identified to the south and west of the site and are believed to have occurred as post-faulting flows. These basalts and interflow zones are believed to be stratigraphically similar to basalt flows identified at the Monsanto Site by Golder (1985 and 1992a). However, the hydrogeologic characteristics of the basalt flows between the two sites appear to be different. Notable differences include:

- Magnitudes of hydraulic conductivities of the basalt flows and interflow zones at the TRONOX site are relatively similar based on the results of extensive aquifer testing,

whereas basalts and interflow units at the Monsanto site are indicated to differ substantially;

- Local water level elevation and water quality differences exist between adjacent shallow, intermediate-depth and deep wells at Monsanto. Water quality and aquifer test data for TRONOX indicate that the entire thickness of saturated basalt is in relatively good vertical hydraulic connection over the area of the TRONOX site, and;
- Faults are considered to represent zones of increased transmissivity at the TRONOX site, whereas they are interpreted to be barriers to flow at the Monsanto site.

2.1.3.1 Hydraulic Conductivities of the Basalt Aquifer

Primary permeability of unbroken basalt is small. Most ground water in basalt is transmitted along secondary features such as joints or fractures. Vertical columnar joints are a common feature observed in basalt exposed to the south and southwest of the site along the trace of the Finch Spring Fault. The presence of intensely fractured or vesicular zones, rubble zones, and/or cinder zones can also greatly increase the ability of basalt to transmit water. Interflow zones are comprised of subaerial deposited materials, including clays, cinderaceous deposits, alluvial sands and gravels, organic debris and weathered and broken basalt. Variations in the ability of interflow zones to transmit water result from changes in the character and thickness of these materials.

Observed hydraulic conductivities estimated from the slug, specific capacity, and pumping tests conducted in the shallow, intermediate-depth, and deep wells include the following:

- Basalts ranged from 8 to 340 ft/day;
- Interflow zones ranged from 90 to more than 200 ft/day.
- Basalts and interflow zones together ranged from 2 to more than 100 ft/day.
- Basalt No. Qb₅ (shallow basalt represented by shallow well screened zones) ranged from about 9 to 340 ft/day.
- Basalt No. Qb₃ (Deeper basalt screened in wells KM-10, KM-11, KM-12, and KM-18) ranged from 8 to almost 100 ft/day.

Hydraulic conductivities estimated for well KM-19 screened in Basalt No. Qb₂ and Interflow Zone No. I₁ ranged from about 15 to almost 70 ft/day.

Generalizations about hydraulic conductivities observed within the basalt aquifer at the TRONOX site include the following:

- The hydraulic conductivities of interflow zones are not significantly greater than those of the basalt flows;
- Hydraulic conductivities of the shallower basalts (Basalt No. Qb₅) are generally greater but not significantly greater than those of the deeper basalts (Basalt No. Qb₃);
- A horizontal layer of significantly smaller hydraulic conductivity which could greatly limit or prevent vertical movement of ground water was not identified;
- A continuous horizontal layer of significantly larger hydraulic conductivity along which horizontal ground water flow could be localized was not identified;
- Hydraulic conductivities in the shallow wells on the east side of the plant (KM-1, KM-2, KM-3, and KM-4) range from 90 to 270 ft/day and appear to be greater than hydraulic conductivities in shallow wells on the west side of the plant (KM-5, KM-8, KM-9, and KM-13), which range from 9 to 48 ft/day.

2.1.3.2 Estimated Ground Water Velocities

Horizontal hydraulic gradients within the shallower basalt aquifer vary from 0.01 feet per foot in the eastern part of the site to 0.03 feet per foot in the western part of the site. Effective porosities have been reported for the basalts of the Snake River Plain aquifer of southeastern Idaho to range from about 8 to 10 percent (Robertson, 1974; Lewis and Goldstein, 1982; Isherwood, 1981; Nace et al., 1959). If an effective porosity of 8 percent and range of hydraulic conductivities of 5 to 270 ft/day is used, then a range of estimated ground water particle velocities of 0.6 to 34 ft/day can be calculated for the eastern part of the plant site. The effective porosity of 8 percent and the observed range of hydraulic conductivities of 9 to 340 ft/day on the western of the site yield a range of estimated ground water particle velocities of 3 to 130 ft/day for the western part of the plant site.

2.2 Current Direction and Rate of Ground Water Flow

Ground water flows in response to hydraulic gradients from areas of higher hydraulic head to areas of lower hydraulic head at rates that are proportional to hydraulic conductivity and hydraulic gradient and inversely proportional to effective porosity of the aquifer. Ground water can flow vertically through aquifers or between aquifers in response to vertical hydraulic gradients and horizontally within aquifers in response to horizontal gradients. Ground water in the Shallow Aquifer System generally flows southward from the topographically higher Blackfoot Reservoir (about 12 miles north of the TRONOX facility) to seeps and springs along the topographically lower Bear River.

Horizontal hydraulic gradients and ground water flow directions within the shallow basalt units at the site are indicated by water level elevations measured during May 2007 and are contoured on Figure 1-2. Site gradient averaged about 0.02 ft/ft in 2007.

The predominant flow direction beneath the plant site is to the west-southwesterly, as shown on Figure 1-2. The western ground water flow direction beneath the site is caused by pumping from the Monsanto production wells located west of the TRONOX site. Ground water levels beneath the east side of the facility suggest a more southerly flow component, with flow beneath the east side of the facility directed towards well KM-3. This subtle change in flow direction may be the result of capping the calcine in 2001. Previous annual evaluations indicated a flatter and more westerly overall flow pattern for this area.

Water level elevations measured during May 2007 in the deeper monitor wells KM-11, KM-12, and KM-18 are also shown on Figure 1-2 but are not contoured. Ground water levels in the deeper wells indicate a pattern of ground water flow that is similar to the pattern observed in the shallow wells.

2.3 Site Water Levels and Site Precipitation

Figure 1-3 presents annual rainfall totals for Soda Springs, Idaho between 1990 and 2006, obtained from Tigert Airport in Soda Springs. Annual totals peaked at about 17.5 inches in 1994 and 1997. Annual precipitation rates declined after 1997 to about 11.5 inches in 2001. Annual precipitation rates have been increasing on average since 2001, to just over 15 inches annual average in 2005 and 2006.

Site ground water level changes over time correlate with variation in the annual average precipitation, rates, although general rises in site water levels lag the precipitation by about three years, based on the observation of the low annual average in 2001 and recovery in water levels in site wells after 2004. Overall, water levels dropped on average 5 to 8 feet between 1997 and October 2001, and then remained at lowered levels in the fall through 2004, as indicated on Figure 1-4. Water levels recovered several feet between 2004 and 2007, towards the range of levels observed in 1997. This recovery may have affected concentrations in a number of wells. Seasonal water levels are typically higher by about 2 to 3 feet in the spring when compared with the fall water levels.

3.0 GROUND WATER SAMPLING

3.1 Ground Water Point of Compliance

The Record of Decision (EPA, September 1995) stated that the point of compliance (POC) for the evaluation of the selected remedial actions for ground water will be the boundary of the current active industrial facility, using the existing monitoring wells (EPA, 1995). During the RI, TRONOX placed monitor wells at strategic locations to monitor specific impoundments, aquifer units, downgradient off-site locations, and the facility as a whole. Locations of on- and off-site well placements and screen location depths were presented in previous technical memoranda and work plans.

During 2004, TRONOX purchased the Hopkins property to the south of the former industrial facility. This property includes the areas containing the monitoring wells KM-15, KM-16, KM-17, and KM-18, that have been designated the “off-site” wells in all previous documents. The off-site designation is continued in this document, referring to wells that are located off of the industrial facility, as established by EPA.

POC wells include wells KM-2, KM-3, KM-5, KM-8, KM-9, KM-11, KM-12, KM-13, and KM-19. EPA requested the addition of wells KM-2, KM-3 and KM-11 to the list in their May 6, 1997 correspondence and TRONOX included POC sampling for these wells. Table 3-1 provides the justifications used for sampling of POC wells at the site, and for sampling off-site well and spring locations.

3.2 Ground Water Sampling and Analysis Plan

A ground and surface water sampling plan was developed for the RD/RA sampling events for on-going semiannual sampling. This plan was finalized and accepted by EPA during May 1997. An additional low-flow sampling plan was developed during September 1997 to incorporate low-flow sampling methods described below.

3.2.1 Low-Flow Purge Sampling Methods

TRONOX installed stainless steel submersible pumps in each of the sampling wells during October 1997. A pump was installed in KM-7 during May 2000. These pumps are dedicated for evacuation and sampling purposes. Each pump is operated by a portable generator system. Each pump is suspended on Schedule 80 1-inch PVC piping and a stainless steel safety cable (in intermediate depth and deep wells), such that the intake level on each pump is placed in the approximate center of the well screened interval.

Low-flow well purging was first performed during the November 1997 sampling round following dedicated pump installation in each of the sampled wells. Low-flow sampling methods are based on EPA Region 1 "Low Flow SOP" dated May 13, 1996 and the EPA document "Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures" dated April 1996. This method was provided as an addendum to the RD/RA Sampling and Analysis Plan (SAP) deliverable submitted to EPA during May 1997 and approved by Region 10 EPA on June 6, 1997. Low-flow sampling is performed on all of the "KM" series wells with the exception of non-POC wells KM-1 and KM-10. Wells KM-1 and KM-10 are monitored for water level purposes only.

During sampling, flow rates are measured concurrent with drawdown in each well to assess stabilization of purged ground water. A discharge assembly is used to control the rate of discharge from each well via use of a ball valve. The assembly is used to control discharge from each well during sampling such that the amount of discharge will not allow the well to be drawn down more than 0.3 feet during purging and sampling events.

Field measurements are made through the use of a turbidity meter and flow cell. The flow cell is used to measure pH, temperature, specific conductance, and dissolved oxygen. Field data are graphed following sample collection to show stabilization of field parameter measurements with time prior to sample collection. These graphs are

presented with the semiannual data validation reports. Criteria used to determine whether the purged water has stabilized include:

- pH within ± 0.3 units;
- Temperature to within ± 2 degrees;
- Specific Conductance within ± 10 percent;
- Dissolved oxygen within ± 10 percent, and;
- Turbidity within ± 10 percent.

If the parameters do not stabilize to meet the above criteria within the extraction of three casing volumes, then a sample is obtained following the removal of not more than three casing volumes. Samples are collected from the discharge point beyond the ball valve. Samples are collected and handled in accordance with the May 1997 SAP.

3.3 QA/QC Data Review

QA/QC review is performed on a semiannual basis after receipt of the data from the lab. Results of the QA/QC data review are presented in the semiannual data validation report, and are not included in this annual ground water review.

4.0 RECENT GROUND AND SURFACE WATER QUALITY

Recent ground and surface water quality refers to the results of samples obtained between the dates of May 14 through May 16, 2007 the (May 2007 sampling round).

4.1 Background Water Quality and Type

Upgradient off-site springs and wells were sampled during the RI, but are no longer sampled. The reader is encouraged to refer to the RI report (Dames & Moore, 1995). Locations sampled from background for the TRONOX site included Formation Spring, and several other private wells to the north and east of the site. These background locations have not been sampled since 1991 since clean-up performance is based on the POC wells.

TDS concentrations are about 500 mg/l in background wells and springs. The largest reported TDS concentration from background locations was 579 mg/l in Formation Spring. The pH values measured at the background locations are near neutral and ranged from 6.8 to 7.4 units. Specific conductance ranged from about 840 umhos/cm in the private wells to about 970 umhos/cm in Formation Spring.

Reported background chloride concentrations are about 3.9 mg/l. Background sulfate concentrations are in the range of about 40 mg/l. Nitrate concentrations range from 0.11 mg/l in Formation Spring to 0.75 mg/l in private wells. Concentrations of aluminum, arsenic, chromium, manganese, molybdenum, nickel, selenium, and vanadium are less than detection at upgradient private wells and springs located to the east of the site.

Background ground water quality and type was characterized during the RI using the trilinear diagram classification method developed by Piper (1944). The Piper diagram consists of two ternary fields (triangles) for plotting percentages of cations (left triangle) and anions (right triangle), and a central diamond-shaped composite field for plotting the relative contribution of the major ion pairs. Based on the Piper plots, the site background

water type plots in a specific pattern and can be classified as calcium-magnesium bicarbonate-type water.

4.2 Common Ion Distributions in Ground Water

The Piper plots evaluated during the RI indicated a mixing of background-type waters beneath the site with pond seepage and contributions from leachate produced in the vadose zone. Water flowing onto the site is relatively high in calcium and low in sodium and potassium. Waters are also compositionally high in bicarbonate. Waters mixed beneath the site increase substantially in sodium, potassium, sulfate and chloride (Dames & Moore, 1995).

4.3 General Ground Water Quality Parameters

4.3.1 pH

The pH range in wells across the site historically indicated neutral to slightly alkaline conditions in the past. Between 1999 and 2001, field pH was found to be lower in many of the wells near the reclaimed S-X pond including samples from wells KM-6, KM-7, KM-8, KM-12, KM-19, and near the reclaimed scrubber pond (KM-2, KM-3, KM-4, and KM-11). The lower ground water pH (range of 6.1 to 6.9) likely had some affect on concentration trends for metals during the 1999 through 2001 period, causing small metals concentration increases during this period. Current site distribution of pH is shown on Figure 4-1. During the May 2007 sampling event, pH indicated decreasing units of concentration from east to west across the site, with the lowest pH in the vicinity of well KM-8.

4.3.2 Total Dissolved Solids

Ground water TDS concentrations in on-site wells ranged from slightly less than 500 mg/l in wells KM-1 and KM-10 (previous results) to about 11,000 mg/l (current) in well KM-8. The secondary drinking water standard for TDS (500 mg/l) was exceeded in

most of the TRONOX POC wells. Recent concentrations of TDS are shown in Figure 4-2. TDS is elevated in shallow wells surrounding the reclaimed scrubber pond, located to the south of the calcine tailing area that was capped in 2001. Concentrations of TDS in intermediate-depth well KM-11 is within the range of background. Beneath the west side of the site, TDS concentration in well KM-8 is substantially larger than nearby wells KM-9 and KM-13 which are within the range of background TDS concentrations. TDS is elevated above background in wells KM-6 and intermediate depth well KM-12 near the S-X pond. TDS concentration in deep well KM-19 (510 mg/l) is also within the range of background.

At off-site ground water locations, TDS concentrations are elevated in wells KM-15 through KM-18, ranging from 590 to 700 mg/l. Finch Spring, located approximately 4400 feet south of the TRONOX site, indicates a TDS concentration of 530 mg/l, while Big Spring is was slightly greater at 640 mg/l.

4.3.3 Turbidity

Turbidity was measured in the field during low-flow purging of the wells. Results of turbidity for the 2007 sampling events are summarized in Table 1 and presented graphically in Appendix A of the May 2007 Laboratory Data Quality Report (GET, September 19, 2007). Although turbidity is generally not considered an indicator of ground water contamination, excessive turbidity in an unfiltered sample can bias analytical results causing reported total metals concentrations to be unrepresentative of true concentrations in ground water. Turbidity is a measure of the solids and suspended organic material in a sample and is reported in nephelometric turbidity units (NTUs).

May 2007 turbidity ranged from 0.45 NTUs in well KM-17 to 12.2 NTUs in well KM-8. Well KM-8 frequently exhibited increased turbidity throughout its sampling history. Turbidity was reduced following redevelopment and removal of large amounts of sediment from this well in February 2000.

4.4 Selected Major Ions in Ground Water

4.4.1 Chloride

May 2007 concentrations of chloride are shown on Figure 4-3. The secondary drinking water standard for chloride is 250 mg/l. Reported chloride concentrations in shallow wells range from 5.7 mg/l in KM-1 (previous sampling) to 2000 mg/l (recent) in KM-8. Chloride was predominant in the S-X and scrubber ponds before these impoundments were removed from service. May 2007 ground water chloride concentrations are elevated relative to background near the reclaimed scrubber pond as indicated on Figure 4-3. Wells to the southwest and west of the S-X pond, respectively have near-background chloride concentrations while nearby well KM-8 is two orders of magnitude larger in concentration. Concentrations of chloride in deeper wells, including KM-11 near the former scrubber pond and in wells KM-12 and KM-19 near the former S-X pond range from 9 to 43 mg/l. Chloride concentrations at Finch and Big Spring are 25 and 35 mg/l, respectively. Upper and Lower Ledger Spring chloride concentrations range from 4.2 to 4.8 mg/l and represent background levels.

4.4.2 Nitrate Plus Nitrite

Prior to the October 1995 sampling round, samples were analyzed for nitrate, nitrite, and nitrate plus nitrite. Results indicated that nitrite concentrations are relatively small in comparison with nitrate. Currently, only nitrate plus nitrite is analyzed. The primary drinking water standard of for nitrate is 10 mg/l. Nitrate plus nitrite concentrations at Upper and Lower Ledger Springs is currently 0.44 to 0.87 mg/l, representative of background concentration for the basalt aquifer.

Nitrate plus nitrite concentrations from the May 2007 sampling round are presented on Figure 4-4. Increased nitrate concentrations are centered about well KM-8 to the south of the covered S-X pond, and in another ground water area beneath the site centered to the

south west corner of the calcine cap. Nitrate plus nitrite exceeding 5 mg/l extends beyond the industrial facility boundary to the south and southwest of the site towards well KM-15. Nitrate is noted to be larger than background concentration at Finch Spring (3.2 mg/l) and at Big Spring (4.6 mg/l).

4.4.3 Sulfate

Sulfate indicates a similar ground water trend to chloride and TDS. Concentration distribution of sulfate is presented on Figure 4-5. Reported concentrations of sulfate from the May 2007 sample round range from about 37 mg/l in well KM-19 to 6,700 mg/l in well KM-8. Increased concentrations are centered immediately west of the covered scrubber pond and to the south of the covered S-X pond. Sulfate concentrations in the deeper wells are elevated with respect to background concentration, and range from 64 to 120 mg/l. The secondary drinking water standard for sulfate (250 mg/l) was exceeded in monitor wells KM-3, KM-4 and KM-8. The largest sulfate concentrations in ground water are associated with areas infiltrated by the former S-X raffinate stream. Off-site concentrations of sulfate are elevated above background in wells KM-15 through well KM-18, ranging from 85 to 130 mg/l.

4.5 Selected Metals in Ground Water

4.5.1 Arsenic

Recent ranges of arsenic concentrations in TRONOX monitor wells are summarized in Table 1-2 and are shown on Figure 4-6. Concentrations in ground water range from less than detection in on-site wells to 90 ug/l in well KM-8 near the reclaimed S-X pond. Recent distribution of arsenic in on-site wells shows that arsenic is detected in wells around the reclaimed scrubber pond. Shallow wells KM-2, KM-3 and KM-4 near the former scrubber pond are 10 ug/l or greater in concentration. Samples collected from off-site wells and springs were less than the arsenic method detection limit.

4.5.2 Manganese

Manganese concentrations are decreasing with time in nearly all of the wells. Recent manganese concentrations in TRONOX monitor wells are summarized in Table 1-2, and are shown on Figure 4-7. Recent manganese concentrations in ground water for on-site wells range from less than detection in well KM-19 to 5,000 ug/l in well KM-8. The RBC for manganese (180 ug/l) was exceeded in two POC wells, KM-3 (560 ug/l) and KM-8 (5,000 ug/l). Manganese does not exceed the RBC at off-site well locations. Manganese was reported to be less than the detection limit to 2.6 ug/l at Upper and Lower Ledger Spring. Manganese was also less than the detection limit Finch and Big Springs during May 2007.

4.5.3 Molybdenum

Molybdenum concentrations indicate an overall decreasing trend with time. Recent molybdenum concentrations in TRONOX monitor wells are summarized in Table 1-2 and are shown on Figure 4-8. Molybdenum was a dominant metal in the S-X raffinate stream, and therefore is found in larger ground water concentrations near former pond sources. During May 2007, on-site well concentrations of molybdenum ranged between 23 ug/l in well KM-19 to 41,000 ug/l in well KM-8. Figure 4-8 illustrates that concentrations of molybdenum are elevated in areas centered to the south of the former S-X pond and to the south of the covered scrubber pond. Molybdenum exceeds the RBC (180 ug/l) in all of the on-site wells with the exception of wells KM-9 and KM-19. The molybdenum RBC is exceeded at all off-site TRONOX well locations, and at Finch Spring and Big Spring. Molybdenum was less than the detection limit in Upper and Lower Ledger Spring during May 2007.

4.5.4 Vanadium

Vanadium concentrations in ground water appear to be decreasing with time at most locations, but at a slower rate of concentration change when compared with arsenic, manganese, and molybdenum. May 2007 ground water vanadium concentrations in the TRONOX monitor wells are summarized in Table 1-2 and are plotted on Figure 4-9. Distribution of vanadium in the ground water is similar to nitrate plus nitrite distribution.

Vanadium was a dominant metal in the S-X raffinate stream. Vanadium is detected at concentrations above the RBC (260 ug/l) in all of the on-site wells with the exceptions of intermediate well KM-11 and deep well KM-19. Vanadium concentrations range between 10 ug/l in KM-11 to 18,000 ug/l in well KM-8. Figure 4-9 illustrates similar distribution trends to nitrate plus nitrite concentration in ground water, with the larger concentrations identified near the south end of the reclaimed S-X pond and west of the calcine cap and the covered scrubber pond. Vanadium concentrations in off-site TRONOX monitor wells located southwest of the site exceed the vanadium RBC. Off-site well KM-17 (18 ug/l) remains substantially below the RBC for vanadium.

During May 2007, the vanadium concentration in Finch Spring was elevated (58 ug/l), but much smaller (2.5 ug/l) at Big Spring. Vanadium was less than the detection limit of 10 ug/l in Upper and Lower Ledger Springs.

4.6 Organic Compounds in Ground Water

As noted during the RI (Dames & Moore, 1995), COC semi-volatile organic compounds that include tributyl phosphate (TBP) and total petroleum hydrocarbons (TPH) originated from the No. 1 fuel oil carrier used in the solvent extraction (S-X) process and found in the S-X raffinate stream. These compounds were detected in the former ponds and in the ground water. POC wells were sampled for total petroleum hydrocarbons and for semi volatile compounds for the detection of TBP through 1999. Organics were sampled in all POC wells in May/June 2002 as requested by EPA for evaluation in the 5-year review.

Organics are not sampled at off-site locations. Currently, only well KM-8 is sampled for organics.

4.6.1 Total Petroleum Hydrocarbons

TPH provides screening level estimates of total organic compound concentrations within certain hydrocarbon ranges but does not identify or provide concentrations of specific organic compounds. TPH was analyzed using Method 418.1 through 1999. This method could no longer be used because Freon was discontinued for use in the method by federal regulation. During the May 2007 sampling round, TPH was analyzed using a different extraction under Method SW846 8015B that included analysis for a range of C₁₀ through C₃₆.

Recent TPH concentrations in POC monitor well KM-8 are summarized in Table 1-2. TPH concentration in KM-8 during the May 2007 sampling event was 1.5 mg/l, greater than the RBC (0.73 mg/l), but less than previous results for this well.

4.6.2 Tributyl Phosphate

TBP was used in the S-X raffinate stream and was detected at concentrations above the RBC (180 ug/l) in the wells near the reclaimed S-X and scrubber ponds during 1997. Results of previous analyses in off-site wells suggest that TBP does not exceed the RBC downgradient of the plant facility boundary. During a number of sampling events, TBP was not detected. During 1999, TBP was detected only in well KM-8 at 1400 ug/l. During 2000 and 2001, TBP was not detected in well KM-8. It is probable that some of the unknown compounds in KM-8 may be the result of degradation of the TBP compound. In May 2007, TBP was reported to be 590 ug/l in KM-8.

5.0 CONCENTRATION TRENDS WITH TIME

5.1 General

Plots of concentration versus time are shown on the graphs presented in Appendix A. These graphs of routinely sampled well and spring sites present common ion and general indicator trends, including pH, chloride, nitrate plus nitrite, sulfate, and total dissolved solids. Metals concentration graphs include COC parameters arsenic, manganese, molybdenum, and vanadium. During 2007, graphed organic parameters include TBP and TPH from well KM-8 only.

The charts in Appendix A are annotated, where appropriate, to show periods of pond operation, the approximate time that liquid source elimination (LSE) was implemented as a remedial action, and the time that calcine capping was performed. Observed increases and decreases in ground water concentrations shown on the plots result from:

- Process changes during pond operation;
- Liquid source elimination (LSE), removal of pond sediments and pond reclamation that resulted in decreased concentrations;
- Changes in ground water pH;
- Changes in water ground water levels, and subsequent gradients;
- Advective transport and natural attenuation in the aquifer.

Significant process change events are annotated on the graphs of concentration versus time for the wells. Table 5-1 provides a chronology of process and process pond events, and other site events. A number of these events have resulted in increasing and decreasing concentrations in the wells, as well as short-term concentration increases for a few of the COCs following implementation of the site remedy.

5.1.1 Fate and Transport of Graphed Chemical Parameters

Inorganic constituents evaluated versus time include metals and common ions. Constituents can be non-reactive and move through the ground water, unaffected by biotic (metabolism, such as microorganisms) and abiotic (adsorption, ion exchange, precipitation, hydrolysis, redox) processes. The fate of specific compounds ultimately depends on the reactivity or non-reactivity of the chemical with the media during transport.

Common Ions

Graphs of the non-reactive chemicals include chloride, a member of the halogen group that is one of the most commonly detected anions in natural water. The transport of chloride through the ground water is largely through physical (hydrodynamic) processes. Chlorides travel at essentially the same rate as the ground water (Knox et al., 1993); the graphs indicate that chloride concentration changes quickly to modification in plant operations, LSE and reclamation efforts. Chloride ions can form complexes with a few of the positively charged ionic species, however, these complexes are usually weak, and are generally considered insignificant unless chloride concentrations are very large (Hem, 1978). Chloride is considered one of the best tracer elements, and is widely used experimentally in tracer models. In general, chloride does not enter into reduction/oxidation (redox) reactions, does not form solute complexes with other ions, does not adsorb to mineral surfaces and does not form salts of low solubility.

In the absence of plant growth, nitrate behaves as a mobile anion, similar to chloride (Drever, 1988). Nitrate concentrations can be rapidly reduced in surface waters through assimilation by aquatic plants (National Academy of Sciences, 1977). Attenuating factors for nitrates do not appear significant at the site, and concentrations may be reduced primarily through dilution in the aquifer.

The sulfate ion is chemically stable, and forms salts of low solubility with only a few metals (Hem, 1978). Once sulfate has dissolved in water, it generally remains in solution except where it is anaerobically reduced to sulfide, precipitated in sediment, released to the atmosphere, or incorporated into living organic matter.

Metals

Several processes interact to control the reactivity and rate of transport of compounds in ground water. Metal ions can be strongly adsorbed to mineral surfaces in a porous medium (such as a clayey interflow zone in a basalt sequence), or to rock surfaces exposed by fractures. On the other hand, this would inhibit their transport through the aquifer when complexed with other ions; some metals can be transported at average velocities that are orders of magnitude faster than when not complexed because of changes in the attenuation properties for the complexed metal.

Changes in speciation and reactivity can result from encountering different chemistries within the aquifer. The mobilities of different oxidation states of metals such as arsenic, manganese, molybdenum, and vanadium may also differ by order of magnitude (Allen et al., 1993).

In solution at neutral pH, the stable forms of arsenic would be arsenate oxyanions (Hem, 1978), with the dominant form being dependant on the pH of the water. Inorganic factors that maintain low concentrations of arsenic in water include adsorption by hydrous iron oxide, co-precipitation or combination with sulfide.

The transport and partitioning of manganese in water is controlled by the solubility of the specific chemical form of manganese that is present (USHHS, 1990). The solubility and speciation of manganese oxides in solution is largely a function of pH and redox potential. Manganese can also be subject to microbial activity. The principal anion associated with manganese is carbonate, although in waters with large bicarbonate concentrations,

manganese bicarbonate complexes can be formed. In waters containing an excess of 1000 mg/l sulfate, manganese sulfate may become the dominant species. In extremely reduced water, the fate of manganese tends to be controlled by the formation of poorly soluble sulfide (USHHS, 1990). The tendency for soluble manganese to adsorb to soils and sediments depends largely on the cation exchange capacity and the organic composition of the soil (USHHS, 1990). Soil adsorption for manganese may be significant in the soils at the site, can be highly variable and can span five orders of magnitude, increasing as a function of organic content and ionic exchange capacity with the soil (Baes and Sharp, 1983). At small concentrations, manganese may become fixed by clays, whereas, at larger concentrations manganese may be desorbed by ion exchange with other ions in solution (USHHS, 1990).

Molybdenum is readily soluble in water, and is likely to be more mobile than vanadium in the ground water. Multiple valence states are a complicating factor in molybdenum chemistry. The anionic (molybdate) species are probably predominant in natural water (Hem, 1978).

Vanadium in the ground water at the site is predominantly found in the pentavalent state. Transport of vanadium in water and soil is influenced by redox potential, pH, and the presence of particulate (USHHS, 1990). Vanadium species have a tendency to bind strongly to mineral or biogenic surfaces by adsorption or complexing; hence it can be transported either in solution or in suspension. Adsorption may be the most significant attenuating factor at the site.

5.2 Trends for On-site and Point of Compliance Wells

5.2.1 Common Ions and General Indicators

Parameters including TDS, sulfate, and chloride indicate similar decreasing trends at the on-site non-compliance and POC wells. The pH is also a general indicator that may be affecting metals trends and concentrations noted at some locations in the past.

Based on a review of concentrations versus time for these parameters, the following general observations are made:

pH

Ground water in the vicinity of the reclaimed scrubber pond had neutral to slightly alkaline pH values through early 1999, relatively unaffected by process waters during plant operation or LSE. Following the summer of 1999, a general decrease in pH was noted in the shallow ground water through 2001 and in a few wells in 2002. The pH rose in these wells following 2002 to the neutral range in 2003. Trends between 2003 and the present indicate the ground water beneath the site is in the near-neutral range, with lowered pH in the ground water near well KM-8 through May 2007.

TDS

TDS concentration trends for ground water in wells located near the former pond facilities are contained in Appendix A. Wells located near the former scrubber pond indicate an increase in TDS concentrations through 1995 and then show generally decreasing concentrations following remedial actions to 2007, with a flattening but decreasing trend between 2000 and the present.

During plant operation, increases in TDS concentrations between 1993 and 1995 are attributed to the diverted discharge of the S-X stream into the scrubber pond instead of discharging to the S-X pond. During 1997, the scrubber pond liquid was pumped to the calcine pond in preparation of the scheduled remedial action for this facility. Incidental residual liquid in the scrubber pond was released from the pond near the location of well KM-3 during the stabilization of the scrubber pond solids. As a result, well KM-3 TDS concentrations spiked during 1997 from the effects of the residual liquid ponding at the surface in the near vicinity of the well. TDS concentrations in well KM-3 have decreased since November 1997 following pond closure and reclamation, but ground water

concentrations appear to show seasonal variability between 2000 and the present, unlike other shallow wells in this area.

Shallow wells near the former scrubber pond demonstrated a greater degree of variability in TDS concentrations between sampling events prior to pond closure. All wells continue to indicate overall decreasing trends, although concentrations rose slightly in May 2006. Seasonal increasing/decreasing trends may account for some of the variability between rounds. Intermediate depth well KM-11 demonstrated little variability.

Wells KM-5, KM-9, KM-12, and KM-13 located near the west side of the facility or near the reclaimed S-X pond indicate a general TDS concentration decrease with time, and smaller overall decreases following 2000 as concentrations approach background. Well KM-6 indicated slightly increasing concentrations through 1999, followed by a decreasing TDS trend through 2002, and a flattening of the trend between 2001 and the present. Deep well KM-19 is near background concentration with respect to TDS. Well KM-8 indicates substantial variability with time, and suggests an overall decreasing trend between 1995 and 2005. TDS increased slightly in well KM-8 between 2005 and 2007. Seasonal increasing/decreasing trends may account for some of the variability between rounds.

Chloride

Chloride concentration trends for wells located near the former pond facilities are contained in Appendix A. Currently, chloride concentrations are substantially greater near the scrubber pond than at other site locations, except KM-8.

Ground water in the vicinity of the reclaimed scrubber pond shows an increase in chloride concentration for shallow wells during pond operation through 1995 as a result of S-X stream discharges to this location. Chloride concentrations have decreased to the present. Shallow wells display variable chloride concentrations through 1997

between sampling events as the result of unlined pond operations. Intermediate depth well KM-11 is less affected by pond operational changes and indicates a more even (smoother) trend with time. All wells in this area demonstrate decreases in chloride concentrations between November 1997 and the present. The decreasing chloride trend in KM-2 slowed after 2003. Chloride concentration trends are nearly identical to TDS trends.

Wells located near the west side of the facility or near the former reclaimed S-X pond indicate chloride concentration decreases with time, with a general flattening of the trends since 2001. Well KM-6 chloride concentrations are also decreasing, but remain elevated above other wells in this area. Chloride in wells KM-5 and KM-6 have increased slightly since 2004. Well KM-8 chloride concentrations show seasonal variability with larger concentrations in the fall, but generally decreasing concentrations through 2000, followed by a lack of seasonality in the data to the present. Concentrations of chloride increased slightly between 2005 and 2007 in well KM-8.

Sulfate

Sulfate concentration trends for wells located near the former pond facilities are contained in Appendix A. Sulfate trends for wells located near the reclaimed scrubber pond show decreasing trends that are comparable to chloride. An increase is noted in sulfate concentrations through 1996 as a result of S-X stream discharges to this location. Sulfate shows a general decrease to the present. Concentration increases in well KM-3 in 1997 resulted from incidental residual liquid in the scrubber pond that was released from the pond during remediation and reclamation. As the direct result, concentrations of sulfate in well KM-3 spiked during 1997. KM-3 sulfate concentrations decreased since that time. Sulfate concentrations in wells KM-2 and KM-11 have been relatively steady between 1999 and the present. Sulfate concentrations in well KM-4 indicate decreasing concentration trends since 1997. Well KM-11 was less affected by plant operations, and shows an even (smoother) trend with time and a longer duration of peak sulfate concentrations.

Wells KM-5, KM-9, KM-12, and KM-13 near the west side of the facility or near the former S-X pond demonstrate a concentration decrease with time with a flattening since 2000. Well KM-19 sulfate concentrations decreased to near background concentrations in 1998. Well KM-6 indicated little change with time through 2000, and then began to decrease through 2004, and then rise slightly to the present level. Well KM-8 sulfate concentrations vary with time similar to chloride and TDS trends. Well KM-8 sulfate continued to indicate decreasing trends between 1995 and 2005. Slight increasing concentrations are noted between 2005 and the present. Less seasonal variability in concentration is noted between 1999 and the present. Increased concentrations were noted in the fall during periods of lower water level elevations in this well prior to mid-2000.

Nitrate plus Nitrite

Nitrate plus nitrite concentration trends for wells located near the former pond facilities are contained in Appendix A. Wells KM-3 and KM-11 located near the reclaimed scrubber pond show like concentrations and trends, and a relatively flat trend since LSE was implemented. Well KM-2 shows higher nitrate plus nitrite ground water concentrations than KM-3 and KM-11, with declining concentrations between 1999 and 2003, then a flat with a spike in concentration occurring in 2006. Well KM-4 nitrate plus nitrite concentrations indicate an increasing concentration trend beginning in the fall of 2001 through the present. Current concentrations are within the range of concentrations noted during plant operations in well KM-4.

Shallow wells near the west side of the facility or near the former S-X pond indicated a spike in nitrate plus nitrite concentration between 1993 and 1994 and variable concentrations with time. Most wells show a decrease in nitrate plus nitrite concentration between 1997 through May 2000. Concentrations in KM-5 and KM-6 suggest an increasing trend between 2001 to the present. KM-7 concentrations peaked in 2006 and dropped in 2007. Wells KM-13 and KM-9 also suggest slightly increasing

nitrate concentration since 2004. Deeper wells KM-12 and KM-19 indicate little change with time. Well KM-8 concentrations spiked in 1994 and 1997, and indicated a decreasing trend through 2001. An increasing nitrate trend is noted in KM-8 between 2001 and 2007.

5.2.2 Metals Concentration Trends

Graphs of metal concentrations versus time include the group of metals identified by EPA as COC. COC metals versus time are presented in Appendix A and described in the following sections.

Arsenic

The risk based concentration (RBC) is 50 ug/l for arsenic is based on the ROD. However, during a meeting at the Tronox site in July 2007, the EPA intended to reduce the performance RBC standard to 10 ug/l. On January 22, 2001, EPA adopted a new drinking water standard or maximum contaminant level (MCL) for arsenic of 10 ug/L or 0.010 mg/L, effective January 2006. Based on the most current results, wells KM-2, KM-3 and KM-8 exceed the new EPA standard for arsenic.

Wells located near the former scrubber pond are near the RBC (10 ug/l). Well KM-3 shows a slight increase in arsenic through 1997, primarily during the time-period that the S-X stream was diverted to the scrubber pond. Well KM-2 spiked in 1994 and has decreased since that time. Well KM-4 spiked in 1994 and again during 1997. Concentration spikes may have been related to discharge of the S-X stream to the scrubber pond. Arsenic concentrations have generally been decreasing near the former scrubber pond since LSE and reclamation in 1997, with a flattening of the trend since 1999.

Wells near the west side of the facility or near the former S-X pond indicate an arsenic concentration decrease with time through 1995. Sample results from the October 2007

sampling will use lower detection limits and allow for a better understanding as to the arsenic trend which are less than the current reporting limit.

Well KM-8 indicated an increasing trend between May 1995 when the pond was taken out of service and 2002. The cause for the increase in arsenic concentrations since closure of the S-X pond is unknown. Concentrations of arsenic have decreased between 2002 and May 2006. Concentrations increased again in 2007.

Manganese

Wells located near the former scrubber pond show variable manganese concentrations throughout operation and then small decreases to the present. Increases in the concentrations of manganese during earlier time periods are attributed to S-X stream discharge into the scrubber pond. Wells KM-3 and KM-4 show significant variability between sample rounds through 1997. KM-4 manganese concentrations spiked during 1994 and decreased through the present. Manganese concentrations in well KM-3 spiked during 1997 then decreased with time through 2000. KM-3 is the only well in this group that currently exceeds the RBC for manganese, and indicates steady increasing concentrations between November 2000 and May 2007.

Wells near the west side of the facility or near the former S-X pond indicated a decrease in manganese with time between 1995 and 2000. Trends for manganese have flattened from 2000 to the present, although KM-7 continues to decrease. Well KM-6 indicates considerable variability with time that suggests seasonal trends, although this was less notable between 2002 and 2004. KM-6 indicated an increasing trend between 2004 and 2006 with falling concentrations to the present. Well KM-19 is about at background concentration.

Well KM-8 continues to exceed the RBC for manganese. The KM-8 manganese trend shows decreasing concentration through 1994, and increasing concentrations through 1997. Concentrations of manganese have fluctuated, but generally began to decrease

several years following LSE and reclamation efforts in 1997. Manganese concentrations have risen since 2004 to the present in KM-8.

Molybdenum

Molybdenum concentration trends for wells located near the former pond facilities are contained in Appendix A. Molybdenum trends with time are comparable to sulfate trends. Wells located near the former scrubber pond indicated decreasing molybdenum concentrations with time following LSE and reclamation through 2000. With the exception of wells KM-3, the remaining wells have all indicated slightly decreasing molybdenum concentrations following 2000 to the present. Wells KM-3 molybdenum concentrations have remained steady or showed slight increases between 2000 and 2007. Molybdenum concentrations in well KM-3 spiked in 1997 during the remediation and stabilization of the scrubber pond solids.

Wells KM-5, KM-9, KM-12, KM-13, and KM-19 near the west side of the facility or near the reclaimed S-X pond indicate a concentration decrease with time through 2000, with nearly flat trends to the present. KM-6 indicates an overall decreasing molybdenum trend through 2004, and an increasing molybdenum trend between 2004 and May 2007. Increased concentrations occur during periods of higher water level elevation (spring sampling) in this well.

Molybdenum concentrations in well KM-8 peaked during late 1994. Well KM-8 indicates substantial concentration variability with time similar to the common ion trends and an overall decreasing trend with time following LSE and reclamation events. Trends have been slowly decreasing with little seasonal variation since 2000. Molybdenum concentrations spiked in KM-8 in the spring of 2005, but increased between 2006 and 2007.

Vanadium

Vanadium trends in wells located near the former pond facilities are contained in Appendix A. Shallow wells located near the reclaimed scrubber pond indicate decreasing vanadium concentrations with time following LSE in 1997. Well KM-11 is an order of magnitude below the RBC, and indicates little change since 1997. KM-3 indicates a flattening of the vanadium concentration between May 1998 and May 2001, and a steady or slightly decreasing trend following capping of the calcine. Well KM-4 vanadium concentrations increased substantially through 1997 and decreased with time through early 2000. Well KM-4 vanadium concentrations have increased since 2004 with a large spike in concentration in 2006. Well KM-2 vanadium concentrations increased through 1996 as the result of the S-X discharge to the scrubber pond, and decreased substantially in 1997 when the pond was reclaimed and the calcine pond dried. Vanadium concentrations in KM-2 have risen slightly since 2004.

Wells KM-5, KM-8, KM-9, KM-12, KM-13, and KM-19 located near the west side of the facility or near the reclaimed S-X pond indicate a concentration decrease with time through 2000 or 2001. This decreasing trend flattened through 2007. Wells KM-5, KM-6 and KM-7 have larger ground water vanadium concentrations than other wells in this group (except KM-8). These wells all spiked in 2006. Concentrations of vanadium in KM-6 have generally risen since 2004

Well KM-8 vanadium concentrations began to decrease in KM-8 beginning in 1992 and continue to decrease following LSE in 1997. In May 1998, vanadium concentrations began to increase in KM-8 with an increasing trend through 2004. Concentrations decreased between 2004 and 2006, but rose again in 2007.

5.2.3 Organics

Total Petroleum Hydrocarbons

KM-8 is the only POC well routinely sampled for TPH. TPH concentrations with time for well KM-8 are contained in Appendix A. Concentrations of TPH decreased with time in well KM-8 to less than detection in 1999. During 2000 and 2001, TPH concentrations appear to have increased above historic ranges. Concentrations have decreased since 2000 to current levels of about 1.7 mg/l.

Tributyl Phosphate

KM-8 is the only POC well routinely sampled for TBP. TBP concentrations with time for well KM-8 are contained in Appendix A. Concentrations of TBP decreased through 2005 in well KM-8 following covering of the S-X pond. Concentrations appear seasonal, with larger concentrations generally noted in the spring sampling events. Concentrations have been within the same seasonal range since 2004.

5.2.4 Conclusions of On-Site Well Concentration Trends

Conclusions drawn from the review of on-site well concentration trends include:

- Nearly all on-site wells exceed the RBC for molybdenum and vanadium. Nearly all wells demonstrate decreases in concentration with time, although the decreasing trend for some general indicators and metals has flattened since 2003. Some increases have been noted in a few wells since 2004.
- Concentrations of common ions have generally decreased through 2007 in almost all POC wells following LSE and surface reclamation. Slight increases were noted in several wells in 2007.
- Concentrations of manganese declined following LSE and reclamation to less than the RBC in all on-site wells with the exception of KM-3 and KM-8 that currently demonstrate rising concentration trends.

- Several shallow wells indicate seasonal variability in concentration. For some wells, including KM-6 and KM-8, this seasonal trend diminished between 2002 and 2007.
- TPH continues to slightly exceed the RBC in KM-8, although trends indicate a decline in concentration that is approaching the RBC.
- TBP is currently detected in KM-8, although this TIC was not noted between 1998 and 2001. TBP is also continuing an overall trend of declining concentration.
- Arsenic remains above detection and the revised drinking water arsenic MCL in several shallow ground water wells around the covered scrubber pond and in well KM-8.
- Well KM-8 indicates vanadium concentration increases between 1998 and 2004 but a decreasing trend through 2006. An increasing vanadium trend is noted in KM-6 between 2004 and 2007. A number of wells indicate increased vanadium concentrations in May 2007.

5.3 Off-Site Well Concentration Trends

The following sections provide a discussion of concentration trends with time for the off-site wells (TRONOX wells located beyond the POC), located to the south on the property previously owned by Larry Hopkins, but purchased by TRONOX in 2004. Off-site wells that are now on TRONOX property include KM-15, KM-16, KM-17, and KM-18. Changes in concentration with time are generally smaller in the off-site wells as a function of their greater distance from the site and pond areas that impacted ground water quality.

In general, concentrations and concentration trends observed in paired shallow and intermediate wells KM-15 and KM-18 are nearly identical for a number of parameters. Concentrations decreased steadily in these wells since the time of the remediation of the MAP ponds in 1993. Wells KM-15 and KM-18 appear to be more directly affected by activities on the west side of the plant facility. Well KM-16 indicates seasonal fluctuations and demonstrates more of a delayed response to LSE and pond basin remediation performed between 1995 and 1997. Well KM-17 has been impacted by operations that occurred in the vicinity of the former scrubber pond. Well KM-17 has

large concentrations of common ions, but appears minimally impacted by arsenic, manganese, and vanadium.

5.3.1 Common Ions and General Indicators

Based on a review of concentrations versus time for these parameters, the following general observations are described below. Graphs of concentrations versus time are contained in Appendix A.

pH

Off-site indicate a similar trend to on-site wells, with a general decrease in pH noted in late 1999 through 2001 from previous neutral to slightly alkaline conditions. The pH in the ground water was slightly less than or near neutral in 2007 in wells KM-15, KM-16 and KM-18.

TDS

Paired wells KM-15 and KM-18 have similar TDS concentrations, and show an overall decrease in concentration with time through 2004. Well KM-16 indicates a decreasing trend with time following LSE, but increasing TDS since 2004. Seasonal trends may account for some of the variability between rounds; however, this is less notable following 2000. Increased concentrations occur during periods of higher water level elevation in this well. Well KM-17 has the largest of the off-site well TDS concentrations.

Chloride

Wells KM-15 and KM-18 indicate matching concentrations, and show an overall decrease with time through 2003. The trend has become flat between 2003 and 2007. Wells KM-16 and KM-17 indicate a more direct response to LSE than wells KM-15 and KM-18, which indicated an earlier decrease in chloride. KM-16 indicates a larger

decrease following 1999, but may be increasing since October 2003. Well KM-17 chloride concentrations are the largest identified in the off-site wells. This well has been affected by lateral dispersion from the scrubber pond, and indicates variably decreasing concentrations since pond reclamation in 1997.

Sulfate

Wells KM-15 and KM-18 indicate nearly identical concentrations, and show an overall decrease with time since initial sampling in 1992. This trend flattened in 2000. Well KM-17 sulfate concentration trends appear to be decreasing following LSE and scrubber pond reclamation efforts in 1997, although KM-15, KM-16 and KM-18 have been relatively flat since 2004.

Nitrate plus Nitrite

Concentrations of nitrite plus nitrate decreased following LSE in the off-site wells. Well KM-15 nitrate plus nitrate concentrations spiked during May 1993, then decreased through 2001. Well KM-18 nitrate plus nitrate concentrations spiked during May 1994, then decreased to the recent KM-15 concentration. Well KM-16 indicates a decreasing trend with time, and seasonal increasing/decreasing trends. Concentrations of nitrite plus nitrate increase during periods of higher water level elevations in this well, although this has become less notable since 2000. Well KM-17 demonstrates the smallest variability with time, but indicates an overall decreasing trend. Wells KM-15, KM-16 and KM-18 demonstrate a rising trend since 2001 and seasonally variable concentrations.

5.3.2 Off-Site Metal Concentration Trends

Graphs of metal concentrations versus time include the group of metals identified by EPA as COC. COC metals versus time are presented in Appendix A and described in the following sections.

Arsenic

All off-site wells are well below the detection limit and the RBC for arsenic. Off-site wells are less than the detection limit of 10 ug/l.

Manganese

Off-site wells are below the RBC for manganese. Concentrations of manganese in well KM-15, KM-16, and KM-18 decreased with time from initial concentrations that were greater than the RBC. Well KM-17 manganese concentrations remain low, near the detection limit. Well KM-16 indicates an overall even but slightly decreasing trend with time and seasonal trends between rounds. This trend is less notable since 2000. Increased concentrations occur during spring sampling rounds. Decreases in manganese concentrations in KM-16 show a lag time behind the other off-site wells, and a flattening of the trend is noted beyond 2003.

Molybdenum

All off-site wells currently exceed the RBC of 180 ug/l. Concentrations of molybdenum in wells KM-15 and KM-18 peaked prior to 1995 during pond operation and began to decline after diversion of the S-X stream to the double-lined ponds. Both wells have similar concentration trends and both indicate significant concentration decreases with time through 2000. The trend has flattened somewhat between 2000 and 2007. Well KM-16 indicated a steady molybdenum concentration with time through 1997. Molybdenum concentrations decreased in May 1998, approximately six months following LSE and pond reclamation. Well KM-16 indicated seasonal increasing/decreasing trends through 2001. Increased concentrations occurred in the spring during periods of higher water level elevation. KM-16 molybdenum concentrations slightly increased between 2004 and 2006, and then decreased again in 2007. KM-17 molybdenum concentrations increased between 1998 and 2003 then declined slightly to the present concentrations.

Vanadium

Off-site wells exceed the RBC for vanadium with the exception of well KM-17, which has relatively unchanged concentrations since November 1997. Concentrations of vanadium in wells KM-15 and KM-18 peaked prior to 1993 and began to decline after diversion of the S-X stream to the scrubber pond and elimination of the MAP ponds. Both wells have parallel decreasing concentration trends, with well KM-18 having a consistently lower concentration. Both wells indicate considerable concentration decreases with time through 2000, with a flattening of the trend in 2005. Well KM-16 has the largest vanadium concentration of all off-site wells, and most recently indicates an increasing concentration trend between 2004 and 2006.

5.3.3 Organics

Organics are no longer sampled in the off-site wells. TPH was last sampled during November 1996. Concentrations of TPH remained relatively unchanged with time. Concentrations of TPH during 1996 were reported at the detection limit. TBP concentrations increased through May 1994 in the off-site wells, and then decreased to less than the RBC in October 1995. TBP in well KM-16 was not detected after May 1993.

5.3.4 Conclusions of Off-Site Well Concentration Trends

Conclusions drawn from the review of off-site well concentration trends include:

- Off-site wells exceed the RBC for molybdenum and vanadium (except KM-17 for vanadium), but are below the RBC for arsenic, manganese, and assumed to be below the RBC for organics. Concentrations are indicated to decrease with time following LSE, with the exception of metals concentrations in KM-16 which indicate increases between 2004 and 2006.
- Concentrations of common ions and TDS continue to generally decrease with time following LSE and reclamation. Nitrate plus nitrite concentrations have been rising

in general since 2001 with the exception of KM-17. Concentrations of common ions have flattened or risen in KM-16 between 2004 and 2006.

5.4 Off-Site Surface Water Quality Concentration Trends

TRONOX routinely monitors surface water quality at four spring locations. Sampled springs include Finch Spring, Big Spring, and Upper and Lower Ledger Springs. Finch Spring originates from the base of the Finch Spring Fault scarp, approximately 4000 feet to the south of the TRONOX facility. Finch Spring has been routinely sampled since 1991.

Big Spring is the most distant spring relative to the site, located approximately 4 miles south of the facility and south of the town of Soda Springs and is believed to be impacted from several upgradient sources, including the Monsanto facility. Big Spring emerges from alluvium at the south end of the valley floor and flows into Hatchery Creek and then into the Bear River. Big Spring was first sampled by TRONOX in 1993. Flow from this spring is considerably greater than Finch Spring, although this flow was smaller between 2001 and 2004 due to several years of below normal precipitation. Discharge from Big Spring was approximately 17.6 cfs in May 2007, whereas discharge from Finch Spring ranges from about 10 to 40 gpm. Springs are sampled for general indicator parameters, common ions, and metals. Concentrations versus time graphs for these springs are presented in Appendix A.

Upper and Lower Ledger Spring surface approximately 3300 feet to the southeast of Finch Spring and issue from basalt. During June 2000, EPA requested TRONOX resume routine sampling of Upper and Lower Ledger Springs. These springs were first sampled by TRONOX in 1991. These springs are a source of drinking water for Soda Springs. Sample results with time are presented for Upper and Lower Ledger Springs in Appendix A. Concentrations of metals are typically less than detection in Upper and Lower Ledger Springs, although molybdenum and vanadium are infrequently detected at concentrations near the detection limit.

5.4.1 Common Ions and General Indicators

TDS

TDS concentrations at Finch Spring increased through October 1994 as the result of pond operation at the site and changes in the discharge of the S-X stream. TDS concentrations decreased steadily between 1995 and 2002, with a smaller seasonally-affected decreasing trend between 2002 and 2007.

Big Spring is located at the most downgradient discharge point in the valley, adjacent to the Bear River. Small seasonal trends are noted in the Big Spring TDS data. Concentrations of TDS at Big Spring decreased consistently since 1996 to current levels (630 mg/l) that are comparable to, but slightly greater than Finch Spring. TDS concentrations decreased in Big Spring between 1995 and 2002. Between 2002 and 2007, the decreasing trend became smaller with notable seasonality in the data.

Ledger Springs TDS concentrations were 470 mg/l in May 2007. Lower Ledger generally has indicated slightly larger concentration than Upper Ledger in past sampling events. TDS concentrations at the Ledger Springs are less than the concentrations at Big and Finch Spring, and are more representative of background water quality concentrations. Concentrations appear seasonal, and trends suggest generally decreasing TDS concentration since 2000.

Chloride

Concentrations of chloride at Finch Spring increased through October 1994, peaked again in late 1996, and then decreased in concentration through May 2007 below 1991 levels. Concentrations leveled off in 1999 but then continued a decrease through the present. Chloride is a conservative tracer because transport in ground water is generally through the hydrodynamic process, traveling essentially at the same rate as

ground water flow. Therefore, changes in chloride concentrations at Finch Spring reflect process and remedial changes at the plant.

Chloride concentrations decreased in Big Spring after 1996. Big Spring is located at the most downgradient discharge point in the valley, and decreasing concentrations of chloride may be related to factors affecting water quality not related to the TRONOX facility. The decreasing chloride trend flattened between 2001 and 2007, but continues to decrease with time. The chloride concentrations at Ledger Springs are an order of magnitude less than chloride concentrations at Big and Finch Springs. Chloride concentrations range between about 4 to 6 mg/l.

Sulfate

Sulfate trends at Finch Spring are remarkably similar to the chloride trends. Sulfate peaked in October 1994 and 1996 and decreased to the present concentrations. Changes in Finch Spring sulfate concentrations are related to former S-X stream discharges to the scrubber pond. Concentrations of sulfate at Finch Spring decreased in 2007 to within or below the range of 1991 concentrations. Sulfate trends are essentially flat since 2005. Sulfate concentrations at Big Spring are about double the Finch Spring concentration. Big Spring also indicates a steady decrease with time through 2004, with the current trend essentially flat. The Ledger Springs sulfate concentrations are also lower than Big and Finch Springs, and range from about 30 to 34 mg/l. No trends are noted for sulfate in Ledger Springs.

Nitrate plus Nitrite

Nitrate plus nitrite concentrations are similar at Finch and Big Springs locations, with slightly larger concentration at Big Springs. Both locations suggest slight seasonal trends in the data, with larger concentrations occurring in the fall season. Both locations indicate generally decreasing concentration trends with time through 2001 and a flattened trend between 2001 and 2007. Ledger Spring nitrate plus nitrite

concentrations are an order of magnitude lower than concentrations at Big and Finch Springs, and range between 0.2 and 0.8 mg/l. Nitrate indicates small increasing trends at both springs since 2004.

5.4.2 Metals Concentration Trends

Graphs of metals versus time are presented in Appendix A and described in the following sections.

Arsenic

Arsenic concentrations are less than the reporting limit at all spring surface water locations during 2007.

Manganese

Concentrations of manganese are generally less than, or near the reporting limit at Finch Spring. Concentrations of manganese are 2.6 ug/l at Upper Ledger Spring, and less than detection at all remaining sampled spring locations in May 2007.

Molybdenum

Historic increases and decreases in molybdenum concentrations for Finch Spring were related to changes in the discharge locations of the S-X stream. Concentrations of molybdenum at Finch Spring indicate decreasing trends through 1996. The concentration then increased sharply and peaked in July 1997. Concentrations of molybdenum decreased steadily between 1997 and the 2007.

Molybdenum concentrations increased at Big Spring through 1997 then decreased through 2000. Concentrations of molybdenum increased slightly in 2001, also noted at Finch Spring. The trend in molybdenum flattened in 2003, then continued an overall

decreasing trend through 2007. These trends may reflect, in part, some of the earlier LSE changes made at the plant.

Molybdenum was estimated less than detection at the Ledger Springs in May 2007. Molybdenum has been detected infrequently at levels near or below the reporting limit since 2000.

Vanadium

Vanadium concentrations increased at Finch Spring through 2001. Concentrations of vanadium peaked in Finch Spring during 2001 at 92 ug/l and then began a decreasing trend to 58 ug/l in 2007. Increases in vanadium concentrations at Finch Spring are believed to be the result of operational S-X stream discharges to the scrubber pond. Vanadium concentration at Big Spring was 2.5 ug/l in 2007. Vanadium was not detected at the Ledger Springs in May 2007.

6.0 PROJECTED CONCENTRATION DECAY TRENDS

This section presents an analysis using existing ground water monitoring data to project future trends, and provides an estimate when these concentrations may potentially fall below their respective RBC for molybdenum and vanadium. TBP, and TPH are less than the RBC for all wells except KM-8, and therefore are not considered in this analysis. Arsenic, frequently found to be less than detection in most wells after 1999 is also not projected. There is no clear trend for arsenic in well KM-8 that demonstrates the largest ground water concentration. Manganese is evaluated only for KM-8 because KM-3 demonstrates an increasing trend with time and other wells demonstrate manganese concentrations that are currently less than the RBC.

Projected concentration decay trends are estimated where possible, using a regression trend curve fitted to the real-time monitoring data from wells where the COC currently exceed the risk-based concentration. Only wells exhibiting a decreasing concentration following LSE are considered in the analysis for the projection of concentration decay. This group includes wells on-site wells KM-2, KM-3, KM-5, KM-6, KM-8, KM-9, KM-12 and KM-13; and off-site wells KM-15, KM-16 and KM-18. Results of the analysis are summarized in Table 6-1. Decreasing molybdenum and vanadium trends were less evident in several wells, in part due to increasing trends or recent increasing concentrations in some wells. Most of the wells, both on and off the industrial site demonstrate predictable decreases.

COC concentration trends with time and projected trends for these wells are presented in Appendix B. The time-period selected for each well location varies slightly, and was based on LSE completed in the closest pond basin, or completion of reclamation of a pond basin (annotated on the graphs). Projected trends are based on the post-LSE monitoring period data. The projected period is through the year 2020. This year was selected based on a time length of approximately 25 years after the S-X stream was contained within lined ponds.

6.1 Analytical Method

Existing ground water data were evaluated using a statistical forecast function for exponential decay. A forecast calculates or predicts a future value by using existing values. The predicted value is a y-value (future concentration of a COC in ground water) for a given future date. The known values are ground water data from the wells. A forecast statistically predicts future values based on a regression function of a range of known data or known x- and y-arrays. Regression analysis estimates the relationship between variables, so that a given variable can be predicted from one or more other variables.

Data curves for the ground water concentrations were generated using an exponential function that describes decay of a substance and calculates the least squares fit through points by using the equation:

$$y = ce^{-kt}$$

where:

e is the base of the natural logarithm;

c is a constant at y_0 (initial concentration) at $t = 0$, and;

$-kt$ is a constant for the predicted time, with the minus sign representing decay of concentration with time.

A trendline is generated for the data based on known x-values for the best-fit curve. The y intercept for the regression trendline is set at zero. This is appropriate, based on the observed absence of manganese, molybdenum and vanadium in background ground water quality data.

6.2 Results of Trendline Analysis

Results of the trendline analysis are presented on the graphs in Appendix B. It is possible that future ground water concentration trends may differ from results generated using real-time data. A number of factors can potentially affect future ground water concentrations and trends. These factors may include, among others, changes in ground water pH, significant changes in precipitation, infiltration and site runoff, capping of the calcine, and significant changes in ground water levels related to variable annual rainfall totals.

The minimum range of each graph has been set at the respective RBC where the 2007 ground water concentration exceeds the RBC. Analysis of the forecast trends suggests the following:

- Wells KM-5 and KM-9 were reduced to the RBC for molybdenum in 2003 as predicted by use of these trendlines. However, a recurring exceedence of molybdenum in 2005 and 2006 was observed. Well KM-5 slightly exceeded the RBC in 2007
- Analysis of 2007 data indicates that in most cases, molybdenum and vanadium concentration decreases lag predictions made in 2006 for several of the wells by one or more years, largely resulting from flattening or recent small increases in vanadium and molybdenum noted in the discussion of concentration trends.
- Molybdenum concentrations will continue to decline in most wells in response to LSE and reclamation. Wells KM-12, KM-13, KM-15, KM-17 and KM-18 are projected to fall below the RBC between 2008 and 2015. Wells KM-2, KM-3, KM-6, KM-16 and KM-8 are estimated to fall below the RBC beyond 2015 based on current trends.
- On-site wells and several off-site wells are forecast to exceed the vanadium RBC for a period of ten years or greater following remedial actions completed in 1997. Based on current trends, wells KM-9 and KM-13 are the first wells expected to fall below the vanadium RBC between 2009 and 2011.
- Manganese is estimated to potentially exceed the RBC in POC well KM-8 for greater than 15 years following LSE, in part as the result of a recently rising manganese trend. Well KM-3 will exceed the RBC for an uncertain period. The rising manganese trend in well KM-3 is not occurring in other wells monitoring the covered scrubber pond area.

7.0 CONCLUSIONS

During 1997, TRONOX discontinued discharges from unlined ponds to ground water. Analysis of real-time monitoring data indicates that remediation efforts of the ponds prior to and during 1997 resulted in notable ground water quality improvement at most of the on-site, POC, and off-site well locations. Predicted trends (water quality projections based on real-time monitoring) suggest that a number of TRONOX well locations have the potential to drop below the RBC for vanadium and molybdenum within 10 to 20 years following LSE. Other wells indicate longer periods of time before concentrations fall below the RBC.

Based on a review of water quality through May 2007, recent water quality trends, and predictions of future concentrations, the following conclusions are drawn.

On-site Water Quality Conclusions

- Generally, concentrations of common ions and TDS have decreased with time in the on-site wells. This trend has flattened somewhat between 2000 and the present for a number of the on-site wells near the west side of the facility as these concentrations approach background.
- Increasing concentrations at several wells following 2004 are in part related to rising water levels in the aquifer following years of drought. Seasonal concentration trends noted in some well locations, including KM-6 and KM-8 also appear to be directly related to changes in water levels. These seasonal effects are less discernable between 2001 and in 2007.
- A rising nitrate trend is noted at most well locations near the covered S-X pond. Nitrate plus nitrite concentrations have doubled in well KM-8 between 2001 and 2007. Rising nitrate plus nitrite is also noted in shallow well KM-4 west of the calcine cap and the covered scrubber pond.
- Vanadium and molybdenum continue to exceed the RBC at most of the on-site POC wells and non-POC wells. Wells KM-5 and KM-9 fell below the molybdenum RBC in 2003, but continue to track close to the RBC. Molybdenum and vanadium concentrations are generally decreasing with time in nearly all POC wells, although KM-3 continues to indicate elevated molybdenum levels since 2000.

- A decreased pH in the ground water between 1999 and 2001 may have caused increased metals concentrations in some POC wells during that period. The pH is now near-neutral across the site and at off-site locations, with the exception of well KM-8.
- Concentrations of TBP and TPH slightly exceed the RBCs in well KM-8 ground water. TPH indicates a decreasing ground water trend through 2005 with little change to the present. TBP indicates an overall decreasing trend since LSE was implemented in 1997 through 2004 with a seasonal pattern within this range to the present.
- Arsenic is less than detection at most on-site wells and was identified at small concentration in shallow ground water. Concentrations of arsenic in ground water are above 10 ug/l near the reclaimed scrubber pond. Arsenic concentrations increased between May 1995 and 2002 in the ground water monitored by KM-8, and declined through 2005. Arsenic is less than detection at off-site well locations.
- Manganese concentrations decreased with time in nearly all wells following LSE and remedial actions completed in 1997. Manganese currently exceeds the RBC in two POC wells. Well KM-3 indicates an increasing manganese trend following implementation of LSE. Well KM-8 manganese concentrations are seasonal. Concentrations decreased substantially between 1997 and 2004, but currently are increasing and remain an order of magnitude above the RBC.
- On-site deep well KM-19 was below the RBC for all COC in 2007.
- Predicted water quality for many of the POC wells suggest that molybdenum and vanadium concentrations will exceed the RBC for 10 or more years following LSE.

Off-Site Ground and Surface Water Quality Conclusions

- Generally, common ions and TDS decreased with time in the off-site wells, but this trend appeared to flatten in 2003.
- Increasing concentrations for several constituents in well KM-16 following 2004 appear related to rising water levels in the aquifer following years of drought.
- Concentrations of common ions and TDS decreased in well KM-17 since peaking in 1998. Molybdenum indicates a decreasing trend in this well. Vanadium is less than the RBC.
- Vanadium and molybdenum continue to exceed the RBC in most of the off-site wells. Molybdenum concentrations continued to decrease through 2004 where a

relatively flat trend is noted to May 2007. Vanadium concentrations are also decreasing in KM-15 and KM-18, although vanadium increased in KM-16 between 2004 and 2006.

- Arsenic is less than detection at all off-site well locations.
- Manganese continues to decrease at off-site locations and is less than the RBC at all locations.
- Finch and Big Spring exceed the RBC for molybdenum only. Both locations continue to indicate decreasing trends.
- Vanadium concentrations in Finch Spring are less than the RBC, and vanadium is less than the reporting limit in Big Spring.
- Vanadium concentrations at Finch Spring increased between May 1993 and October 2003. A peak vanadium concentration occurred in October 2001. Concentrations of vanadium have decreased at Finch Spring since that time.
- Water quality at Upper and Lower Ledger Springs does not appear to be impacted from former site operations based on May 2007 water quality results.

COC Trendline Predictions

- Wells KM-5 and KM-9 met the molybdenum RBC as predicted in 2003. However, concentrations of molybdenum in both wells continue to hover near the RBC.
- Molybdenum is projected to fall below the RBC in three of the downgradient POC wells within ten to fifteen years following LSE. Molybdenum concentrations will continue to exceed the RBC at the on-site wells KM-2, KM-3, KM-6 and KM-8 for considerably longer.
- The concentration of vanadium is projected exceed the RBC in most on-site POC wells and off-site wells for fifteen years or more following 1997 LSE actions, with the exception of KM-19 which is already below the RBC. Wells KM-9 and KM-13 are predicted to be near the vanadium RBC within about ten to 15 years following LSE.
- As a result of overall larger concentrations and unclear trends for arsenic and vanadium concentrations, well KM-8 continues to lag other wells in concentration decreases. Therefore, KM-8 will take considerably longer to fall below the RBCs for manganese, molybdenum and vanadium.

8.0 RECOMMENDATIONS

Ground and surface water monitoring will continue at the TRONOX facility on a semiannual basis to assess the effects of remedial changes made at the site as required in the ROD. Field data results should be evaluated when sampling occurs to assess current with preceding site conditions.

The proposed arsenic RBC of 10 ug/l will require a method using a lower reporting limit. We recommend that arsenic analysis should be performed using EPA method 6020 (ICP/MS) for arsenic analysis with a reporting limit of 5 ug/l.

Parameters that fall below the RBC will be evaluated and reported to EPA when these occur. All sampling and analytical results should be reviewed semiannually in accordance with the protocols contained in SW846 and EPA laboratory data validation functional guidelines to assess the quality of the data results. Ground and surface water quality will be appended semiannually to the RD/RA database. Results of the data review will be transmitted to EPA and IDEQ.

All ground water quality trends and predicted water quality should be evaluated in an annual report to assess the improvements to ground and surface water quality. Future annual evaluations will include the incorporation of ground water monitoring data from the Evergreen facility. This facility monitors ground water downgradient of the Tronox property on industrial property owned by the City of Soda Springs. Evaluation of Evergreen data in conjunction with Tronox ground and surface water data will provide an increased understanding of ground water flow paths downgradient of the Tronox site.

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TABLES

**TABLE 1-1
MONITOR WELL CONSTRUCTION DATA**

Well Designation	Well Completion Date	Drilled Total Depth (T.D.) Below Grade (ft)	Boring Diameter (inches)	Steel Casing Depth Below Grade (ft)	PVC Casing Depth Below Grade (ft)	Screen Depth Below Grade (ft)	Sand Pack Interval Below Grade (ft)	Bentonite Interval Below Grade (ft)	Grout Seal Depth Below Grade (ft)
KM-1	10-07-91	56.5	8" 0 to T.D.	0 to 6.5	0 to 45.9	45.9 to 55.9	44.5 to 56.5	39.4 to 44.5	0 to 39.4
KM-2	09-21-91	57.8	8" 0 to T.D.	0 to 37.6	0 to 47.2	47.2 to 57.2	44.7 to 57.8	40.7 to 44.7	0 to 40.7
KM-3	10-11-91	49.5	8" 0 to T.D.	0 to 6.0	0 to 39.1	39.1 to 49.1	36.7 to 49.5	30.5 to 36.7	0 to 30.5
KM-4	10-02-91	54.5	8" 0 to T.D.	0 to 12.1	0 to 43.7	43.7 to 53.7	41.6 to 54.5	36.7 to 41.6	0 to 36.7
KM-5	10-01-91	49.3	8" 0 to T.D.	0 to 3.8	0 to 38.0	38.0 to 48.0	35.9 to 49.3	31.9 to 35.9	0 to 31.9
KM-6	09-24-91	45.3	8" 0 to T.D.	0 to 11.9	0 to 34.7	34.7 to 44.7	31.2 to 45.3	26.4 to 31.2	0 to 26.4
KM-7	09-26-91	56.8	8" 0 to T.D.	0 to 19.6	0 to 46.2	46.2 to 56.2	44.3 to 56.8	39.6 to 44.3	0 to 39.6
KM-8	10-21-91	46.0	8" 0 to T.D.	0 to 10.8	0 to 34.6	34.6 to 44.6	32.4 to 46.0	27.8 to 32.4	0 to 27.8
KM-9	09-29-91	58.3	8" 0 to T.D.	0 to 21.0	0 to 47.5	47.5 to 57.5	45.5 to 58.3	39.3 to 45.5	0 to 39.3
KM-10	10-12-91	121.0	10" 0 to 67 ft 8" 67 to T.D.	0 to 57.0	0 to 100.0	100.0 to 120.0	93.6 to 121.0	88.4 to 93.6	0 to 88.4
KM-11	10-29-91	105.0	10" 0 to T.D.	0 to 18.7	0 to 80.0	80.0 to 100.0	78 to 105.0	73 to 78	0 to 73
KM-12	10-29-91	155.0	8" 0 to T.D.	0 to 7.1	0 to 134.1	134.1 to 154.1	127 to 155.0	121 to 127	0 to 121
KM-13	10-07-91	57.0	8" 0 to T.D.	0 to 22.5	0 to 46.4	46.4 to 56.4	44.3 to 57.0	37.6 to 44.3	0 to 37.6
KM-15	09-24-92	58	10" 0 to T.D.	0 to 5.0	0 to 45.2	45.2 to 55.2	42.8 to 57.0	36.5 to 42.8	0 to 36.5

**TABLE 1-1
MONITOR WELL CONSTRUCTION DATA**

Well Designation	Well Completion Date	Drilled Total Depth (T.D.) Below Grade (ft)	Boring Diameter (inches)	Steel Casing Depth Below Grade (ft)	PVC Casing Depth Below Grade (ft)	Screen Depth Below Grade (ft)	Sand Pack Interval Below Grade (ft)	Bentonite Interval Below Grade (ft)	Grout Seal Depth Below Grade (ft)
KM-16	09-18-92	74.6	10" 0 to 5 ft 8" 5 to T.D.	0 to 5.0	0 to 63.3	63.3 to 73.3	60.8 to 74.6	56.0 to 60.8	0 to 56.0
KM-17	09-25-92	49.1	10" 0 to 5 ft 8" 5 to T.D.	0 to 5.0	0 to 38.2	38.2 to 48.2	36.3 to 49.1	30.9 to 36.3	0 to 30.9
KM-18	10-03-92	180	10" 0 to T.D.	0 to 5.0	0 to 152.6	152.6 to 172.6	150 to 173	145 to 150	0 to 145
KM-19	10-15-92	218	12" 0 to 8 ft 10" 8 to 167 ft 8" 167 to T.D.	0 to 57	0 to 193.6	193.6 to 213.6	190.9 to 214	182.9 to 190.9	0 to 182.9
MW-1	6-63	51.3	NA	NA	NA	NA	NA	NA	NA
MW-2*	6-63	42.4	NA	NA	NA	NA	NA	NA	NA
MW-3*	6-63	42.5	NA	NA	NA	NA	NA	NA	NA
MW-4	6-69	47	NA	NA	NA	37-47	20-47	NA	NA
MW-5	12-72	65	NA	NA	NA	NA	NA	NA	NA
MW-6	12-72	55.2	NA	NA	NA	NA	NA	NA	NA
MW-7	12-72	58	NA	NA	NA	48-58	20-58	NA	NA
MW-8	9-81	76	NA	NA	NA	26-76	20-76	NA	NA
MW-9	9-81	68	NA	NA	NA	28-68	17.5-68	NA	NA

* Well abandoned during Phase I.
NA Not Available

TABLE 1-2
MAXIMUM CONCENTRATIONS OF COC AND MOST CURRENT CONCENTRATIONS
IN TRONOX WELLS AND OFF-SITE SPRINGS

Well Designation	Arsenic Concentrations		Manganese Concentrations		Molybdenum Concentrations		Total Petroleum Hydrocarbons Concentrations		Tributyl Phosphate Concentrations		Vanadium Concentrations	
	PROPOSED RBC = 10 ug/l		RBC = 180 ug/l		RBC = 180 ug/l		RBC = 0.73 mg/l		RBC = 180 ug/l		RBC = 260 ug/l	
	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (mg/l)	Most Current (mg/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)
KM-2*	53	13	444	38	11800	1100	2.0	NA	7	NA	15500	5000
KM-3*	27	13	1680	560	44900	6400	1.8	NA	1400	NA	13200	2300
KM-4	63	10	1160	90	15300	2200	NA	NA	NA	NA	23300	6400
KM-5*	12.2	ND	399	7.1	1460	200	NA	NA	3	NA	15800	1300
KM-6	6.5	6.3	291	180	2140	1400	2.0	NA	110	NA	6630	4500
KM-7	6.9	ND	197	94	593	300	2.0	NA	NA	NA	3410	2100
KM-8*	170	90	8770	5000	165000	41000	9.5	1.5	4442	590	29000	18000
KM-9*	5	ND	113	6.6	1740	160	NA	NA	ND	NA	3590	410
KM-11*	2	ND	157	16	5600	300	0.42	NA	112	NA	492	10
KM-12*	23	ND	177	29	9290	470	0.39	NA	13	NA	5580	660
KM-13*	4	ND	131	7.7	6790	220	0.18	NA	12	NA	6420	520
KM-15	5.6	ND	543	54	6950	450	0.15	NA	484	NA	3840	940
KM-16	7.3	ND	364	110	2300	780	1.9	NA	180	NA	4250	2400
KM-17	1.5	ND	84	2.6	987	350	1.2	NA	170	NA	493	18
KM-18	3.7	ND	332	47	6340	410	1.3	NA	410	NA	2990	720
KM-19*	2	ND	32.3	ND	258	23	1.1	NA	4	NA	558	130
Big Spring	1.1	ND	1.8	ND	508	210	NA	NA	NA	NA	13.6	2.5
Finch Spring	2	ND	4.4	ND	663	190	0.22	NA	ND	NA	91.7	58
Upper Ledger	3.7	ND	2.6	2.6	22.4	ND	NA	NA	NA	NA	5.1	ND
Lower Ledger	4.2	ND	1.5	ND	54.1	ND	NA	NA	NA	NA	14.9	ND

Footnotes:

* = Point of Compliance Well

NA = Not Available – not sampled during May 2007

ND = Not Detected (less than IDL)

Shaded cells indicate exceedence of RBC

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-1 (shallow well paired with KM-10)	Lateral gradient background well	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, No organics	No	None	Background sampling not needed; relying on RBC performance standards at POC wells and no statistical background comparison
KM-2 (shallow well)	Active calcine tailing impoundment/former scrubber pond area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, although not truly downgradient of calcine or former scrubber pond; monitor changes in ground water concentrations in conjunction with changes at active calcine impoundment area and scrubber pond closure
KM-3 (shallow well paired with KM-11)	Reclaimed scrubber pond	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3,4 total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well; monitor changes in ground concentrations water along southern boundary in conjunction with scrubber pond closure
KM-4 (shallow well)	Active calcine tailing impoundment area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1, 3, total chromatographable organics Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Will provide monitoring of calcine impoundment following capping. Not a POC well

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-5 (shallow well)	Historic scrubber pond/historic MAP ponds, Boiler blowdown pond/downgradient of facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, monitors downgradient of northern and central areas of entire plant facility; no active or historic activities downgradient of this location
KM-6 (shallow well)	Historic limestone Settling ponds	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Rounds 1, 3	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Monitors zone of increased transmissivity on the southern boundary of facility; not a POC well
KM-7 (shallow well)	Historic calcine impoundment area	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	No	None	Yes (2000-->)	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Monitors central portion of the facility and provides additional justification for contouring of COC; not a POC well
KM-8 (shallow well paired with KM-12 and KM-19)	Former S-X pond/ downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, metals, radionuclides Rounds 1, 4, total chromatograph-able organics Round 1,3, TPH and semivolts Rounds 4 and 8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-9 (shallow well)	Former S-X pond/downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well, downgradient of entire facility; comparisons can be made with ground water model results to track and evaluate performance
KM-10 (intermediate well, paired with KM-1)	Intermediate depth background well	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	No	None	Background sampling not needed; relying on RBC performance standards at POC wells and no statistical background comparison
KM-11 (intermediate well, paired with KM-3)	Former scrubber pond	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Rounds 1,3, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; No organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with scrubber pond closure
KM-12 (intermediate well paired with KM-8, KM-19)	Former S-X pond/ downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Round 1, total chromatographable organics Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure
KM-13 (shallow well)	Former S-X pond (north end) and downgradient of plant facility	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, radio-nuclides Round 1, total chromatographable organics Round 1	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well, downgradient of entire facility

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
KM-15 (shallow well, paired with KM-18)	Off-site well southwest of former S-X pond and within main area of impacted ground water	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Located in off-site area near modeled point; current RBC exceedences of , Mo, and V
KM-16 (shallow well)	Off-site well south of former S-X and settling ponds	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Located off-site and laterally downgradient of the site; RBC exceedences of Mo, and V
KM-17 (shallow well)	Off-site well southwest of former scrubber pond and active calcine tailing	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Located off-site and laterally downgradient of the site; RBC exceedences of Mo
KM-18 (intermediate well, paired with KM-15)	Off-site well southwest of former S-X pond, pond and within main area of impacted ground water, paired with KM-15	Not completed prior to Round 5	Long-list metals, semivols and TPH Rounds 5-8	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitors deeper aquifer zone for ground water impact; current RBC exceedences Mo, and V
KM-19 (deep well paired with KM-8 and KM-12)	Former S-X pond and downgradient of plant facility	Not completed prior to Round 5	Long-list metals Round 5, short-list metals Rounds 6 through 8, semivols and TPH Round 5	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP; no organics	Point of compliance well; monitor changes in ground water concentrations in conjunction with changes from S-X pond closure

TABLE 3-1

**SAMPLING HISTORY AND SAMPLING RATIONALE FOR REMEDIAL DESIGN/
REMEDIAL ACTION GROUND WATER SAMPLING**

Well/Sample Location	Source Area Monitored	Round 1 Through 8 Sample Events		Round 9 Through 12 Sample Events		RD/RA Sample Events And Low Flow Sampling		
		Sampled? (Yes/No)	Analytes	Sampled? (Yes/No)	Analytes	Sample Site? (Yes/No)	Analytes	Justification For Sampling/Not Sampling
Finch Spring (spring discharging from base of Finch Fault to surface water)	Spring south of facility which has appeared to be impacted primarily from scrubber discharge	Yes	Long-list metals Round 1-3, short-list metals Rounds 4 through 8, long-list metals, semivols and TPH Round 5	Yes	Metals, General Indicators	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor downgradient changes to ground water from scrubber pond closure and other remedial actions on-site, current RBC exceedence of Mo
Big Spring (spring discharging to surface water flowing to Bear River)	Spring south of Soda Springs, furthest south discharge identified from Bear River Basin to Bear River	Not sampled prior to Round 6	Short-list metals	Yes	Metals, General Indicators, no organics	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Current exceedence of Mo RBC, too far from plant to measure direct changes associated with remedial actions; other influencing factor contributing to ground water upgradient of site and downgradient of Tronox, will continue to monitor
Upper Ledge(r) Spring (spring discharging from Ledger Creek drainage, between Kelley Park and Rabbit Mountain)	An important source of drinking water for the town of Soda Springs. EPA requested additional monitoring of this spring by KMC LLC following public meeting and on amended ROD comments in June 2000.	1 Event (no impacts noted)	Long-list metals Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor ground water quality
Lower Ledge(r) Spring (spring discharging from Ledger Creek drainage, between Kelley Park and Rabbit Mountain)	An important source of drinking water for the town of Soda Springs. EPA requested additional monitoring of this spring by KMC LLC following public meeting and on amended ROD comments in June 2000.	1 Event (no impacts noted)	Long-list metals Round 1	No	None	Yes	Table 4-3 of RD/RA GW SAP and QAPP, no organics	Monitor ground water quality

TABLE 5-1
CHRONOLOGY OF PROCESS CHANGES

Event	Date(s)	Comments
S-X stream diverted from the S-X pond to the scrubber pond	1992 through 1993	Flow may have been diverted between ponds during this time period.
MAP ponds taken out of service; third roaster taken off-line in April	1993	Ponds reclaimed. Effects of remediation apparent in well KM-5.
S-X pond receiving discharge from S-X circuit	1994	S-X circuit discharge diverted to S-X pond for last time.
S-X stream diverted from the S-X pond to the scrubber pond	Late 1994 to mid 1995	S-X pond contained residual process water during 1995
S-X stream diverted to newly-constructed lined ponds	Mid 1995	Precipitation continued to fill the S-X pond basin and infiltrate. Pond contained significant volume of precipitation during 1996-1997 winter.
Scrubber pond taken out of service	April 1997	Scrubber pond pumped to the calcine pond. Some scrubber stream sent to calcine ponds. Residual liquid in pond and meteoric water drained out during stabilization of the pond sediments. All baghouses on-line in October.
Discontinue sluicing calcine	April – October 1997	Calcine dewatered, and residual water recycled in process. Dewatered calcine stockpiled north of the calcine impoundment.
Fertilizer Plant Operational	July 1998 to May 2000	Calcine removed from active calcine Impoundment, processed to fertilizer. Reject fertilizer placed in calcine impoundment.
Discontinue Vanadium Processing – Vanadium Plant Idle	January 1999 to present	Discontinue stockpiling of calcine, discontinue all vanadium process streams to lined ponds, discontinue the recycle of roaster reject.
Cap Active Calcine Impoundment	May 2001 through August 2001	Calcine was capped using multi-component cover to eliminate meteoric infiltration through calcine tailing. Substantial amount of dust control/construction water used.
Dismantle Vanadium Plant	November 2001 through May 2002	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade. Footprint regraded with limestone fines in April/May 2003
Dismantle Fertilizer Plant	November 2002 through June 2003	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade.
Reclaim Stormwater Runoff Ponds	September through October 2003	Solids and liquids removed to 10-acre pond, site regraded and reclaimed.
Reclaim 5-Acre Ponds	September through October 2004	Solids and liquids removed to 10-acre pond, east pond site regraded and reclaimed.
Regrade Scrubber Pond Cover	November 2005	Fill and regrade south of calcine cap

Note: Changes in the discharge locations of both the S-X and scrubber streams affected concentrations in both on-site and off-site wells and Finch Spring during operation.

**TABLE 6-1
SUMMARY OF PROJECTED COC TRENDS**

Well Designation	Manganese Concentrations		Molybdenum Concentrations		Vanadium Concentrations	
	RBC = 180 ug/l		RBC = 180 ug/l		RBC = 260 ug/l	
	Most Current (ug/l)	Projected Year Below RBC	Most Current (ug/l)	Projected Year Below RBC	Most Current (ug/l)	Projected Year Below RBC
KM-2*	38	NE	1100	>2015	5000	>2015
KM-3*	560	NE	6400	>2015	2300	>2015
KM-4	90	NE	2200	NE	6400	NE
KM-5*	7.1	NE	200	2008	1300	2014
KM-6	180	NE	1400	>2015	4500	>2015
KM-7	94	NE	300	NE	2100	NE
KM-8*	5000	>2020	41000	>2020	18000	ND
KM-9*	6.6	NE	160	2003	410	2009
KM-11*	16	NE	300	NE	10	NE
KM-12*	29	NE	470	2013	660	2018
KM-13*	7.7	NE	220	2008	520	2011
KM-15	54	NE	450	2009	940	2018
KM-16	110	NE	780	2020	2400	>2020
KM-17	2.6	NE	350	2015	18	NE
KM-18	47	NE	410	2009	720	2015
KM-19*	ND	NE	23	NE	130	NE

Shaded Numbers Indicate Exceedence of RBC

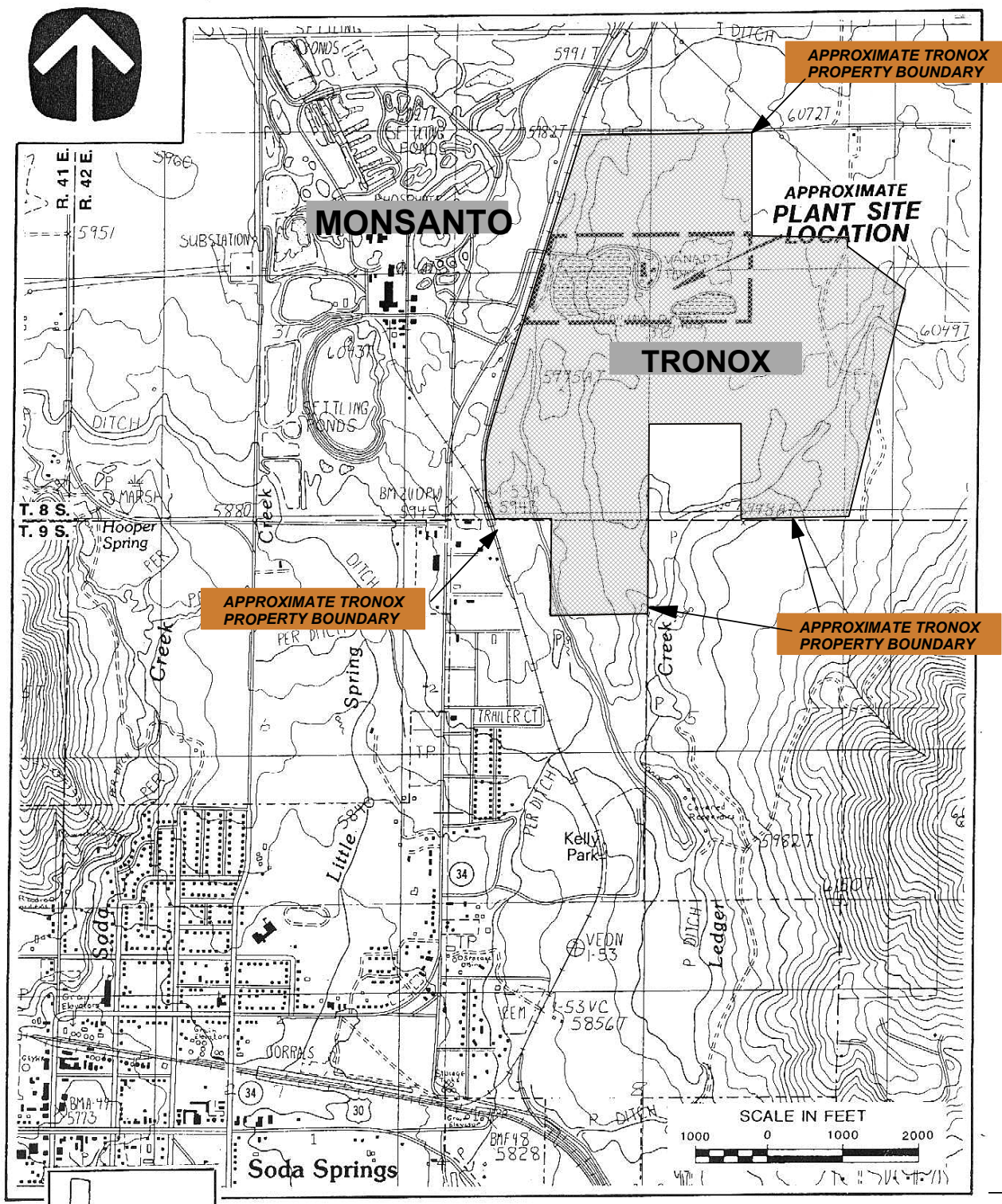
Footnotes:

* = Point of Compliance Well

NE = Well not used for COC projection trend

ND = Can not assess trend based on current monitoring data following LSE

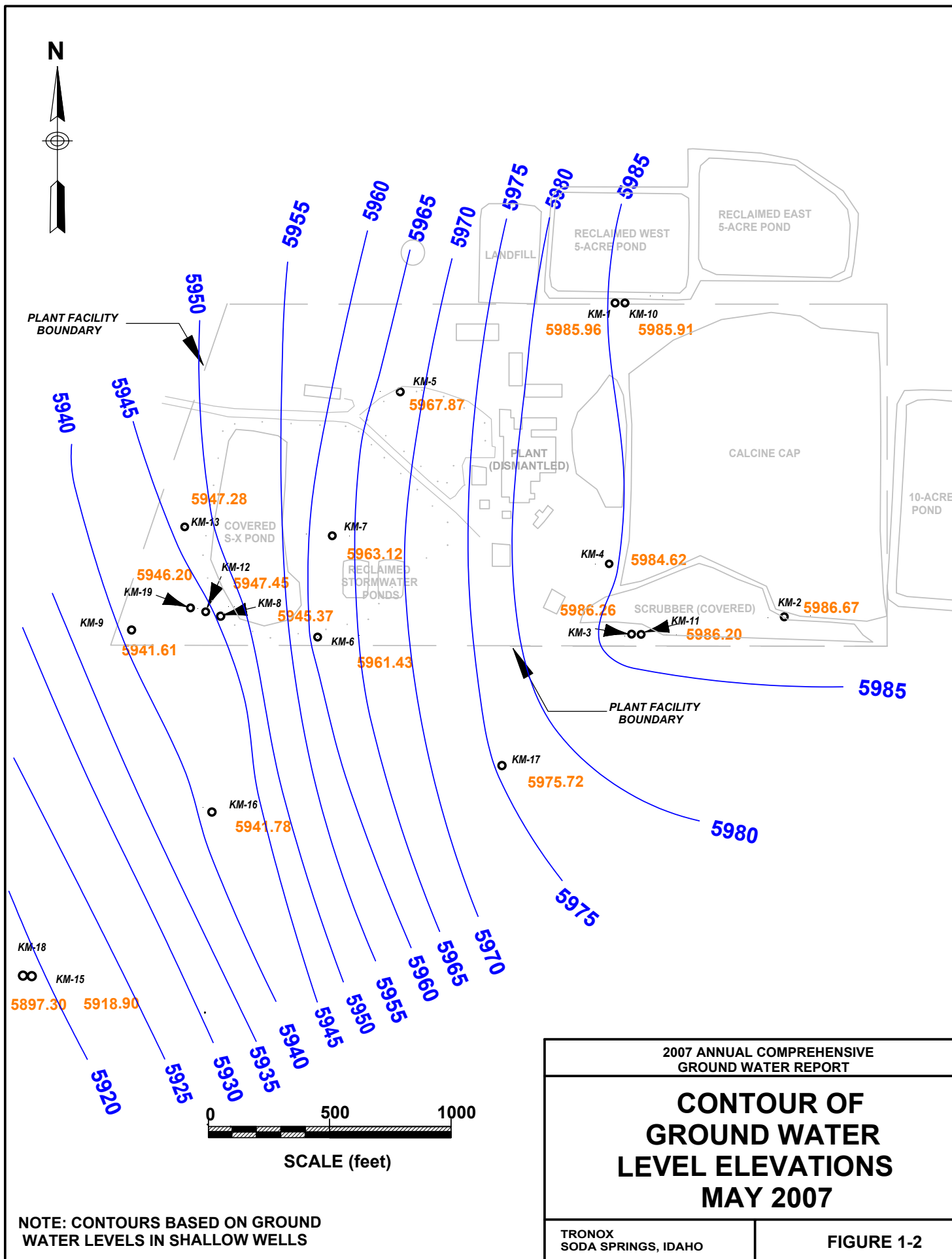
FIGURES

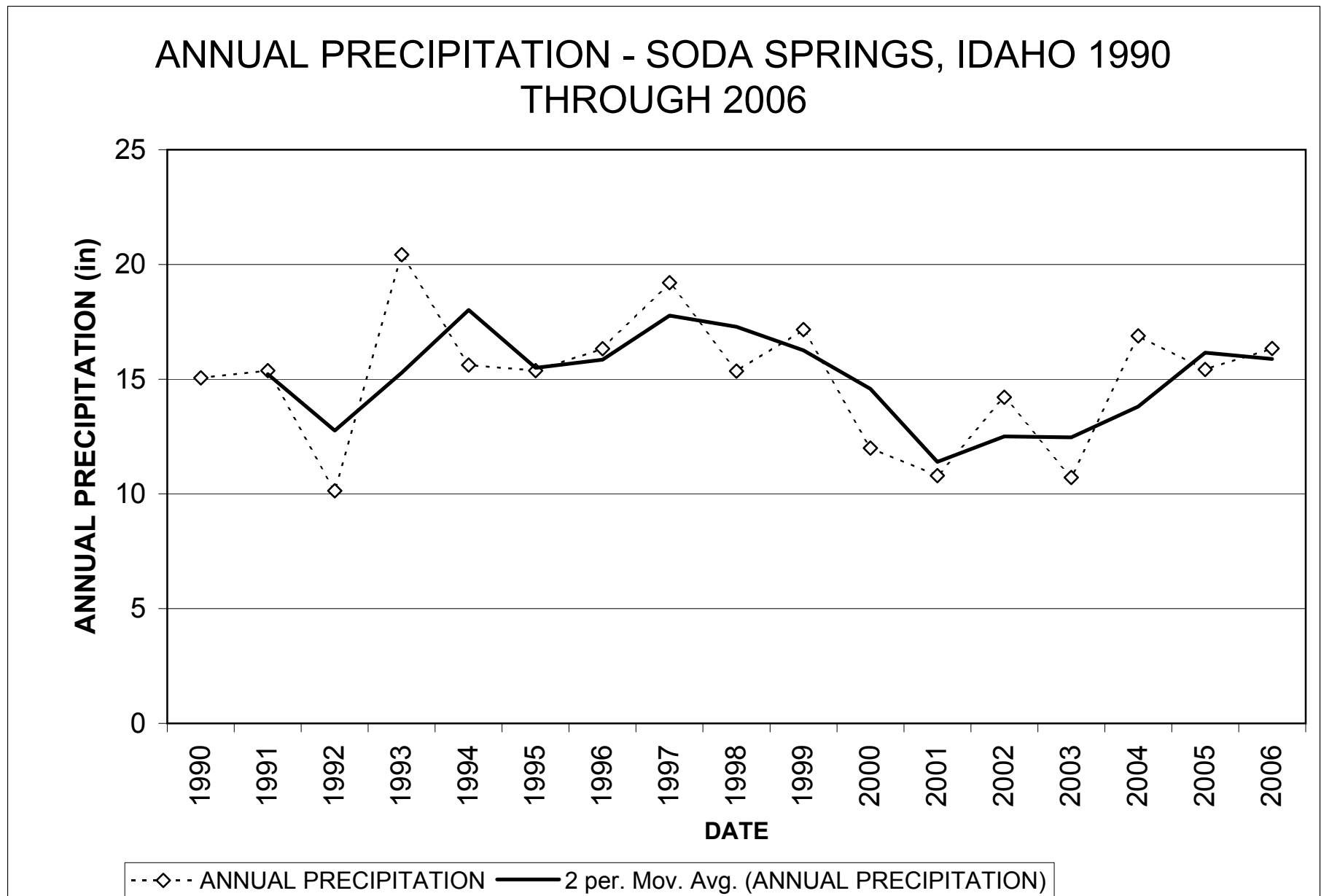


REFERENCE: U.S.G.S. QUADRANGLE
SODA SPRINGS, IDAHO PROVISIONAL
EDITION 1982.

APPROXIMATE TRONOX PROPERTY BOUNDARY LOCATION MAP

FIGURE 1-1





**WATER LEVELS VERSUS TIME
TRONOX ON-SITE WELLS
FOLLOWING LSE AND POND RECLAMATION**

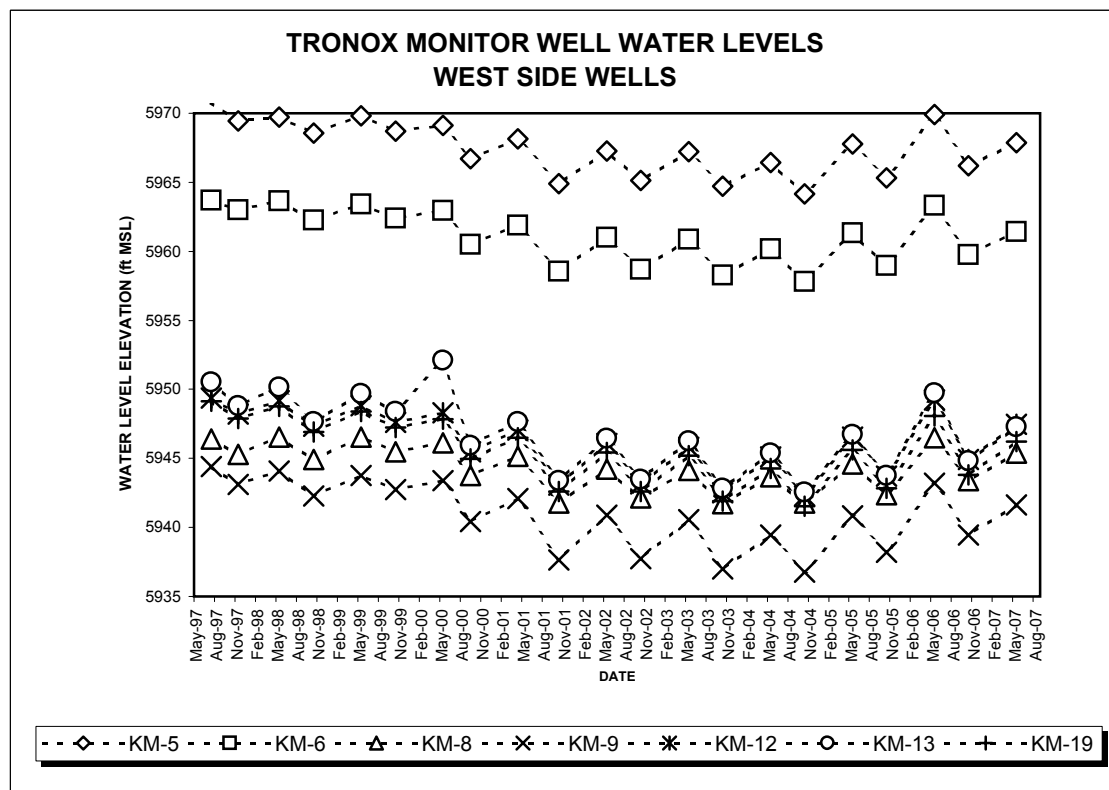
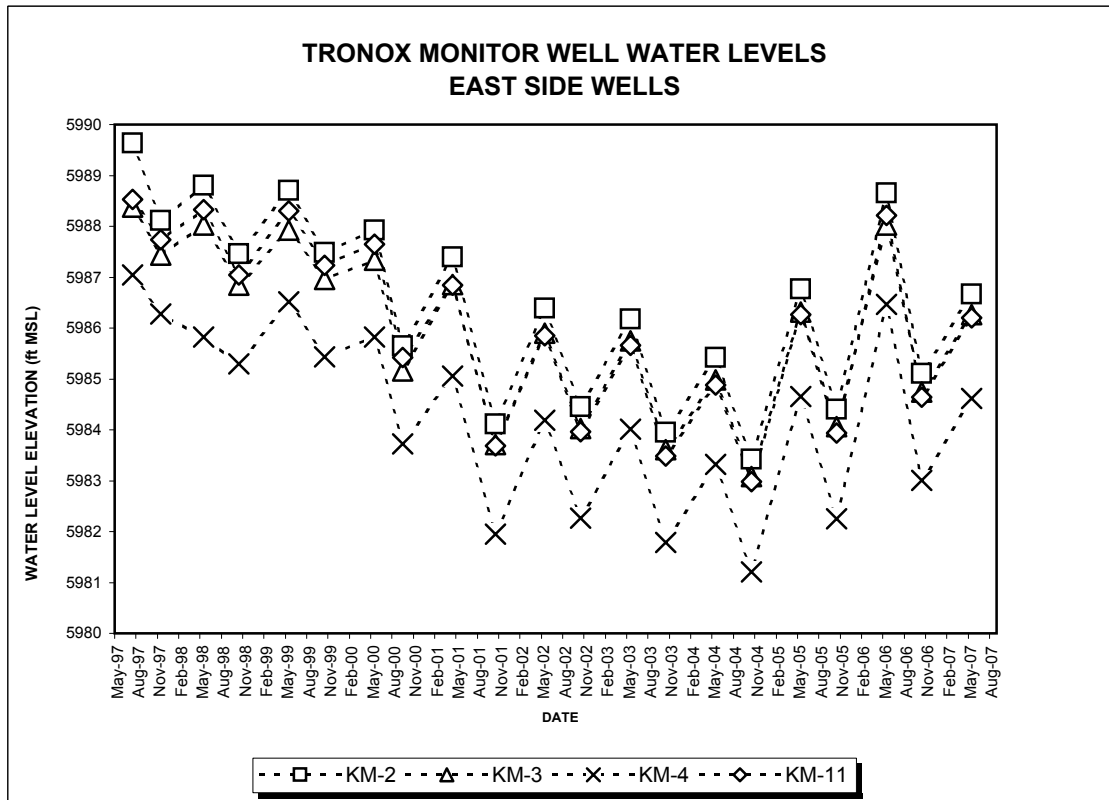
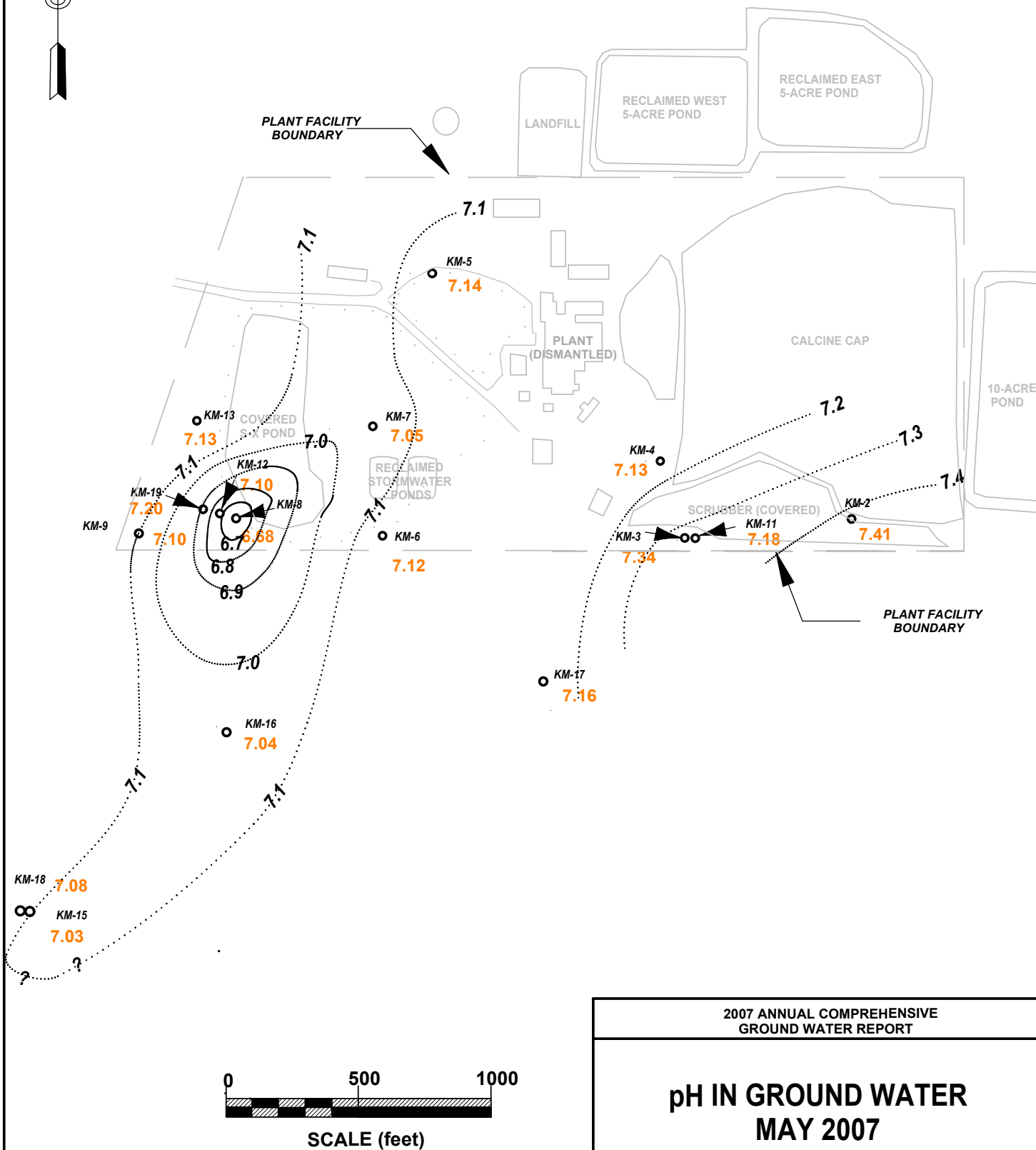


FIGURE 1-4



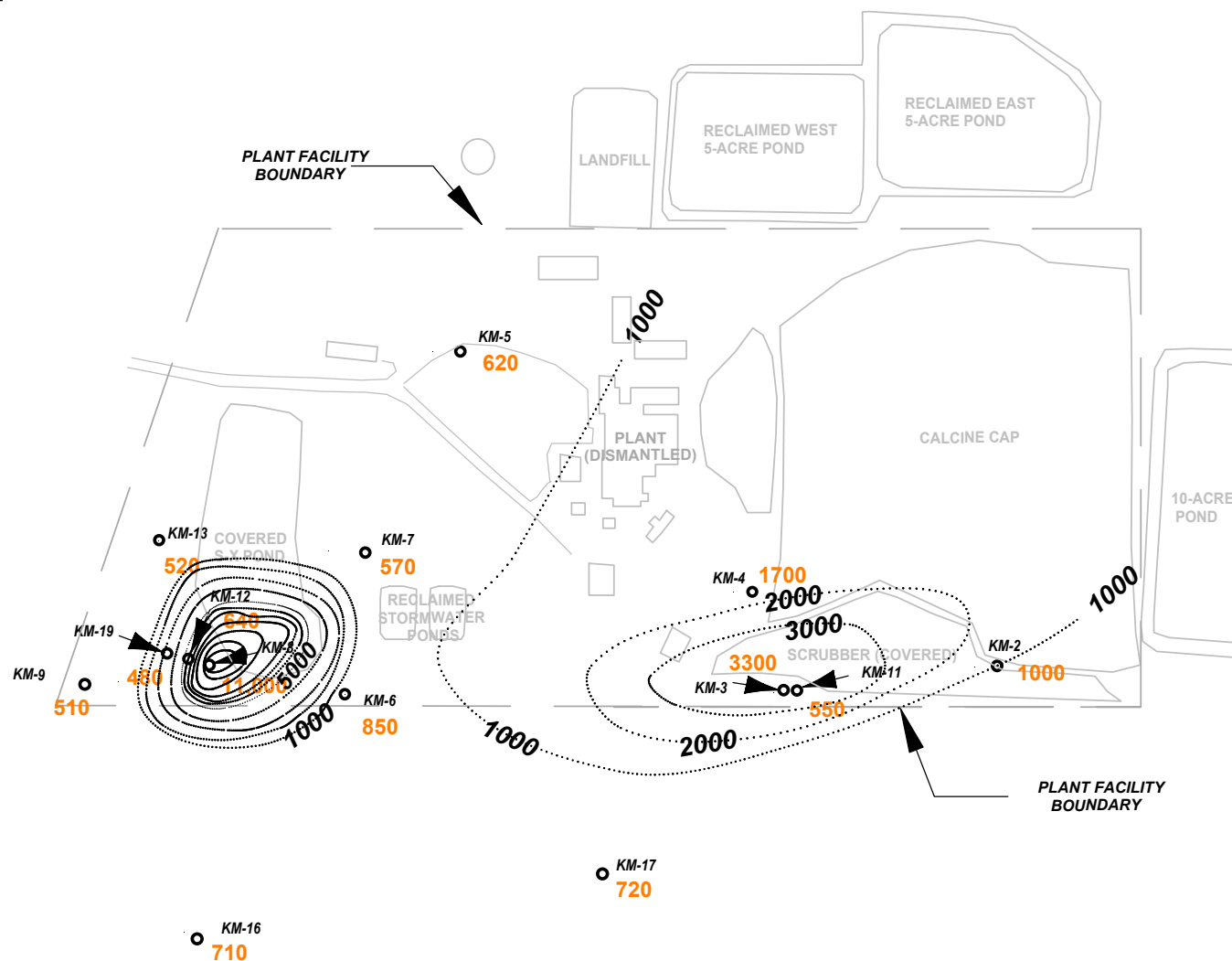
NOTE: CONCENTRATIONS ARE IN pH units.
CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS
IN SHALLOW AQUIFER.

2007 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

pH IN GROUND WATER MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-1



KM-18
590
KM-15
600



SCALE (feet)

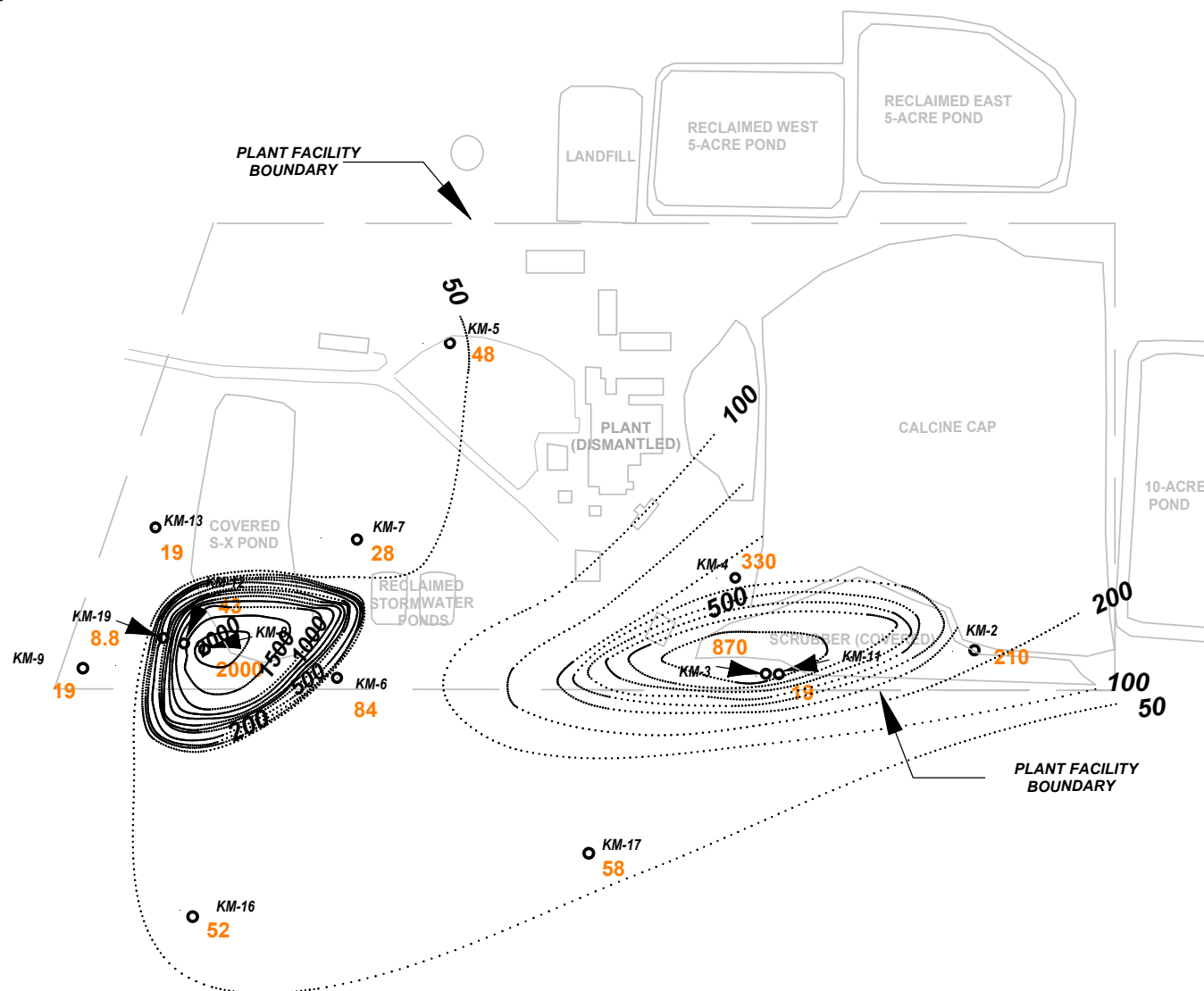
NOTE: CONCENTRATIONS ARE IN mg/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

2007 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF TDS IN GROUND WATER MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-2



KM-18
29
KM-15
32

0 500 1000

SCALE (feet)

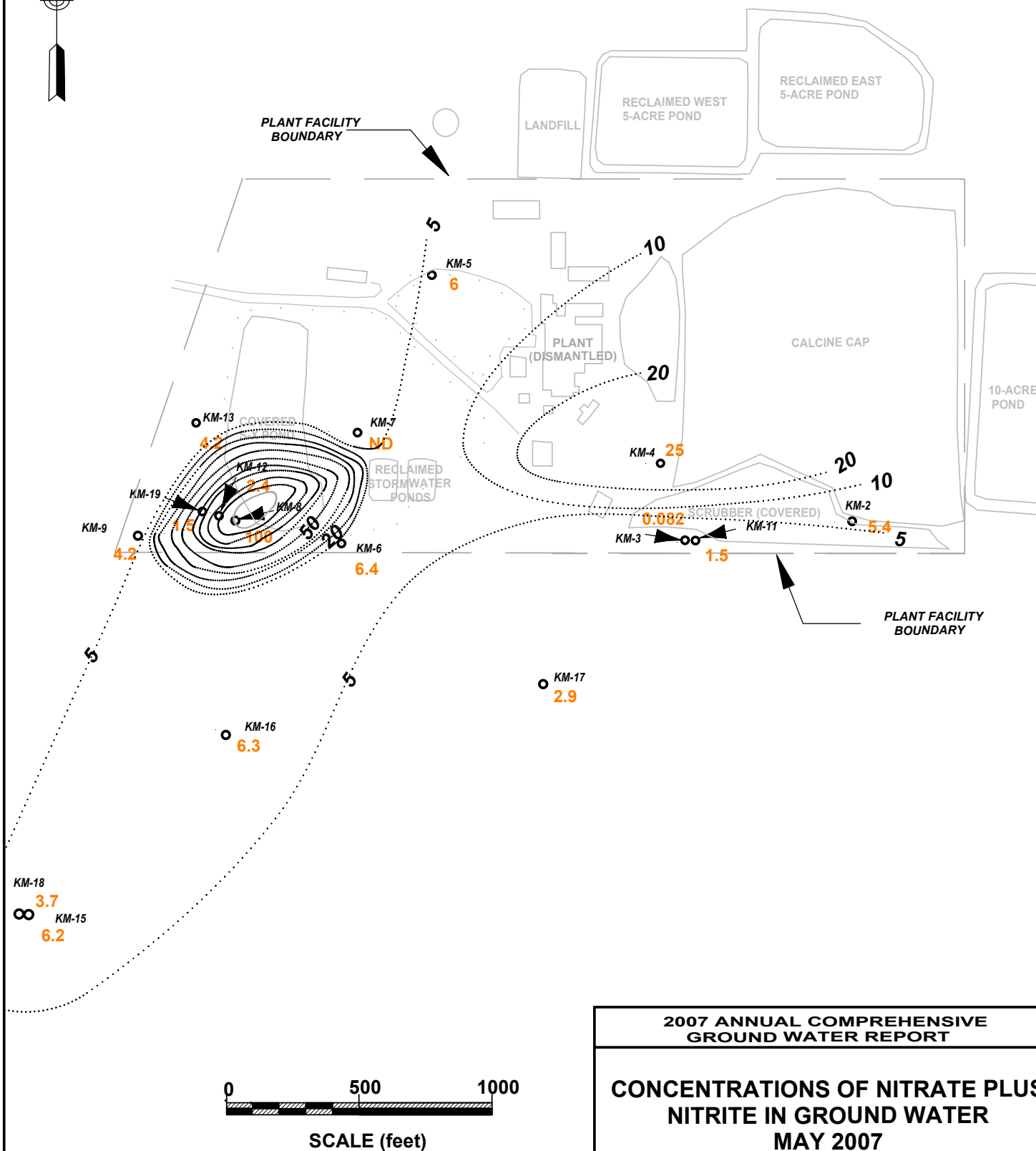
NOTE: CONCENTRATIONS ARE IN mg/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

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CONCENTRATIONS OF
CHLORIDE IN GROUND WATER
MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-3



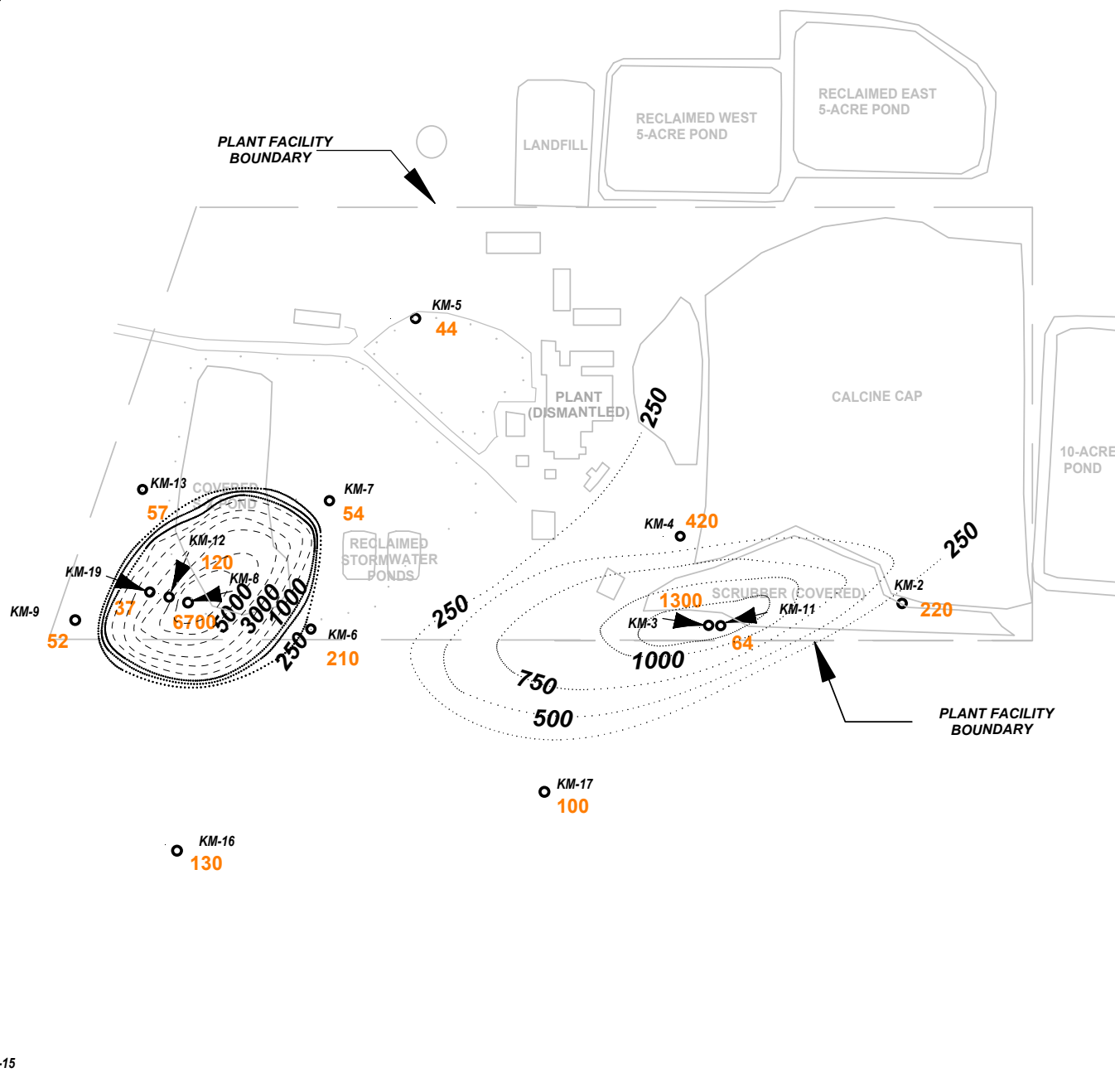
NOTE: CONCENTRATIONS ARE IN mg/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

2007 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF NITRATE PLUS
NITRITE IN GROUND WATER
MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-4



KM-18
85
KM-15
90

0 500 1000

SCALE (feet)

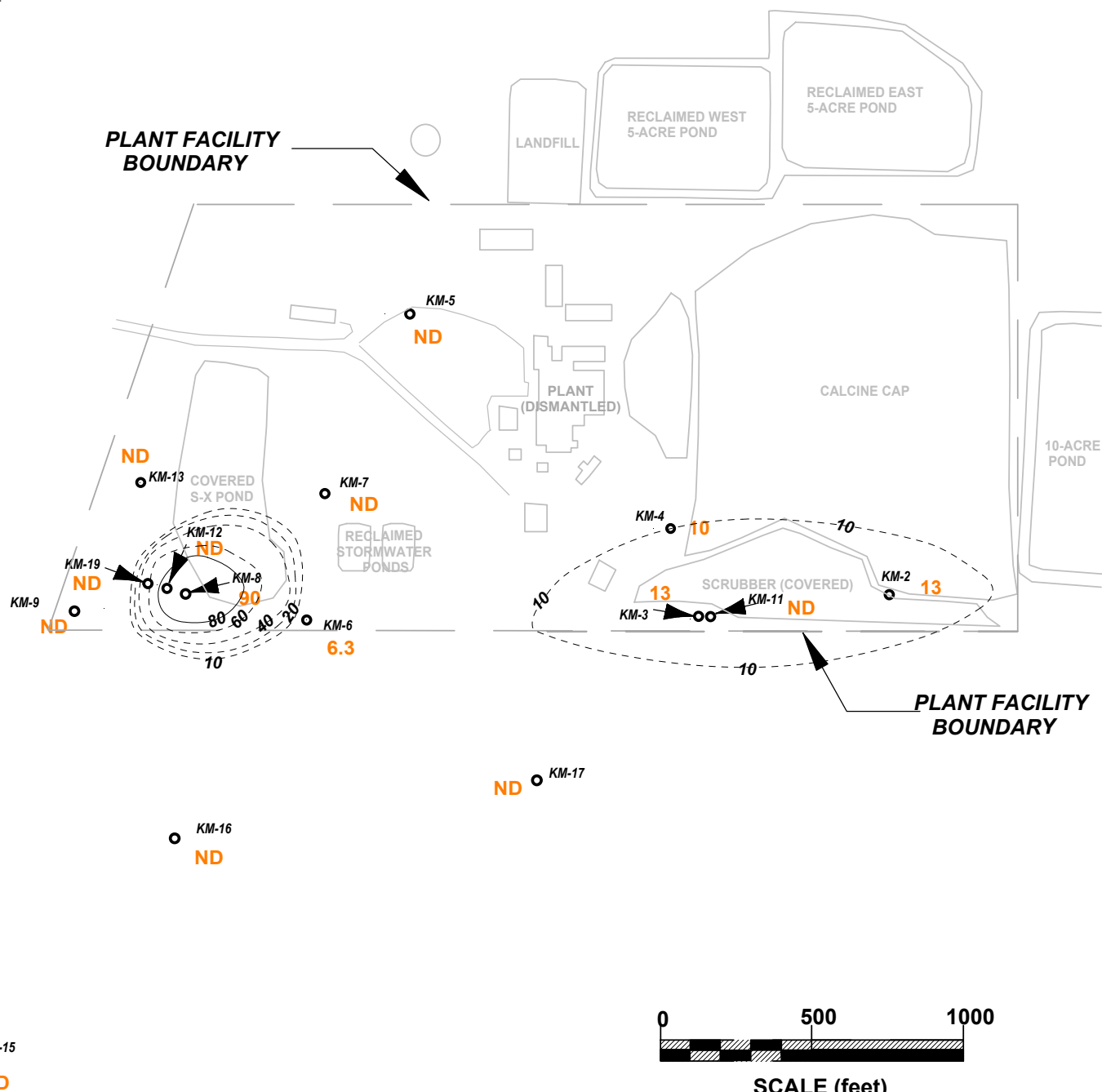
NOTE: CONCENTRATIONS ARE IN mg/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

2007 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF SULFATE IN GROUND WATER MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-5



NOTE: CONCENTRATIONS ARE IN ug/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

PROPOSED RBC FOR ARSENIC IS 10 ug/l

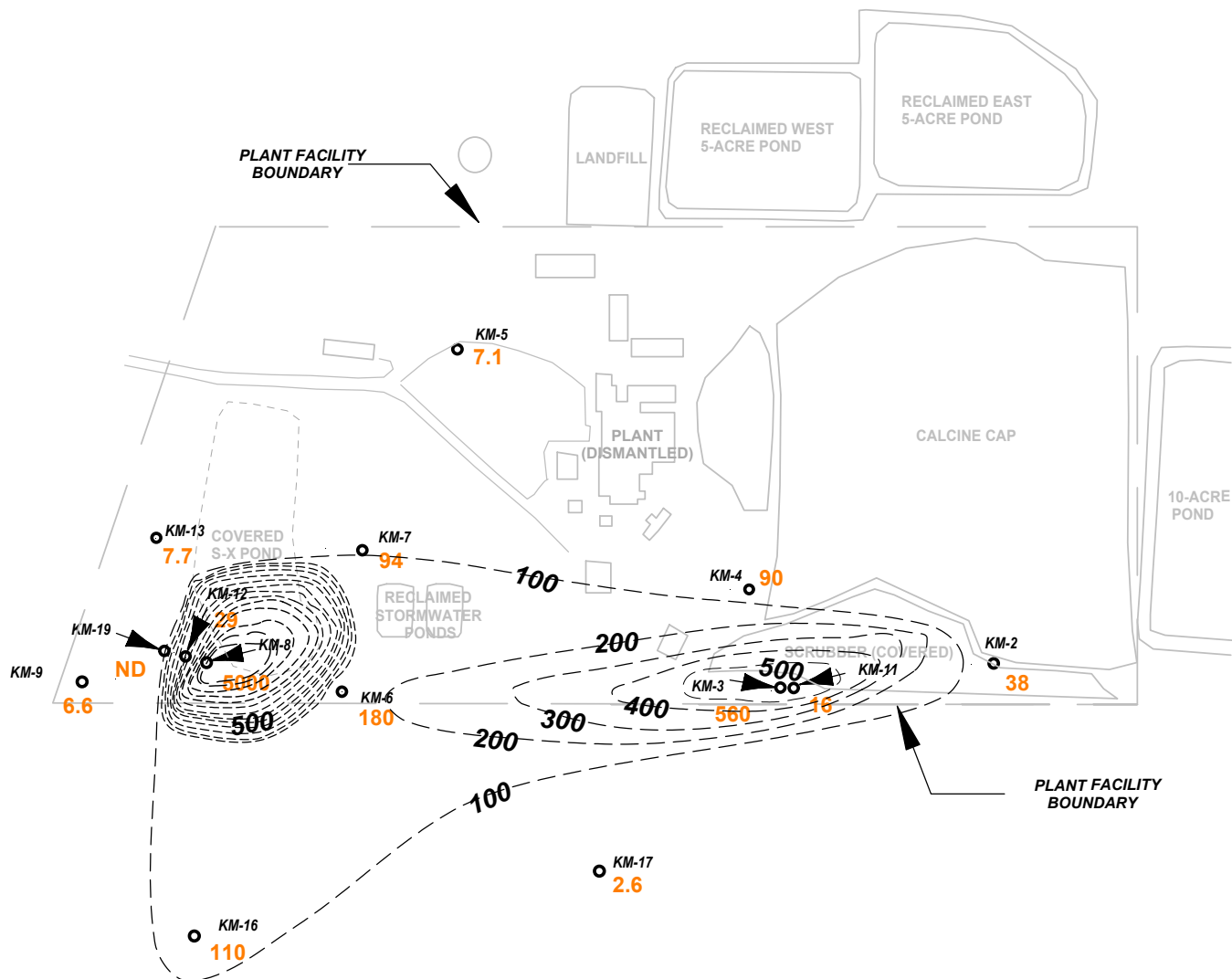
NOTE: CONCENTRATIONS LESS THAN
THE METHOD DETECTION LIMIT
OF 15 ug/l ARE FLAGGED
AS ESTIMATED

2007 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF ARSENIC IN GROUND WATER MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-6



KM-18
47
∞ KM-15
54



SCALE (feet)

NOTE: CONCENTRATIONS ARE IN ug/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

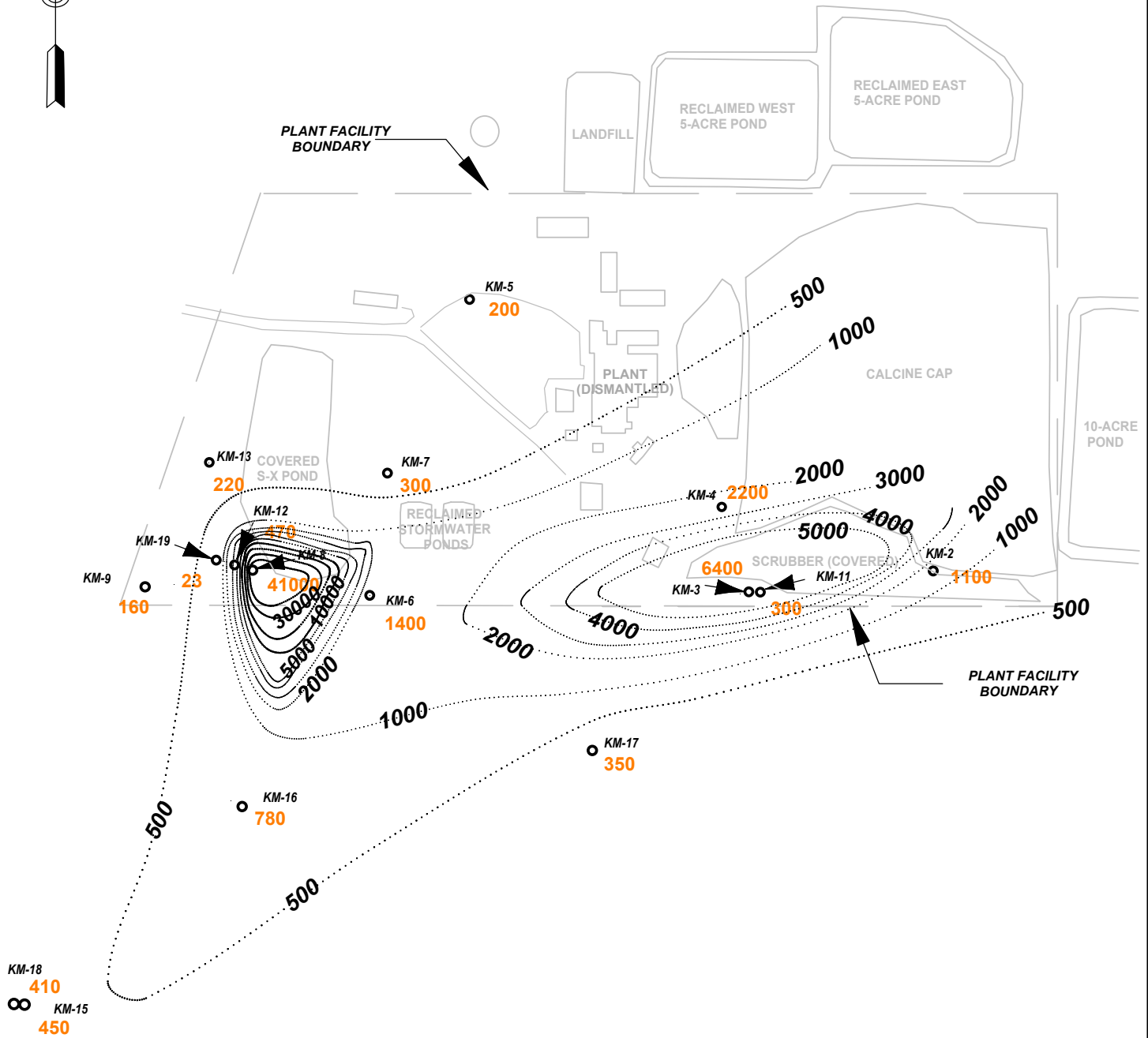
RBC FOR MANGANESE IS 180 ug/l

2007 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF MANGANESE IN GROUND WATER MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-7



0 500 1000

SCALE (feet)

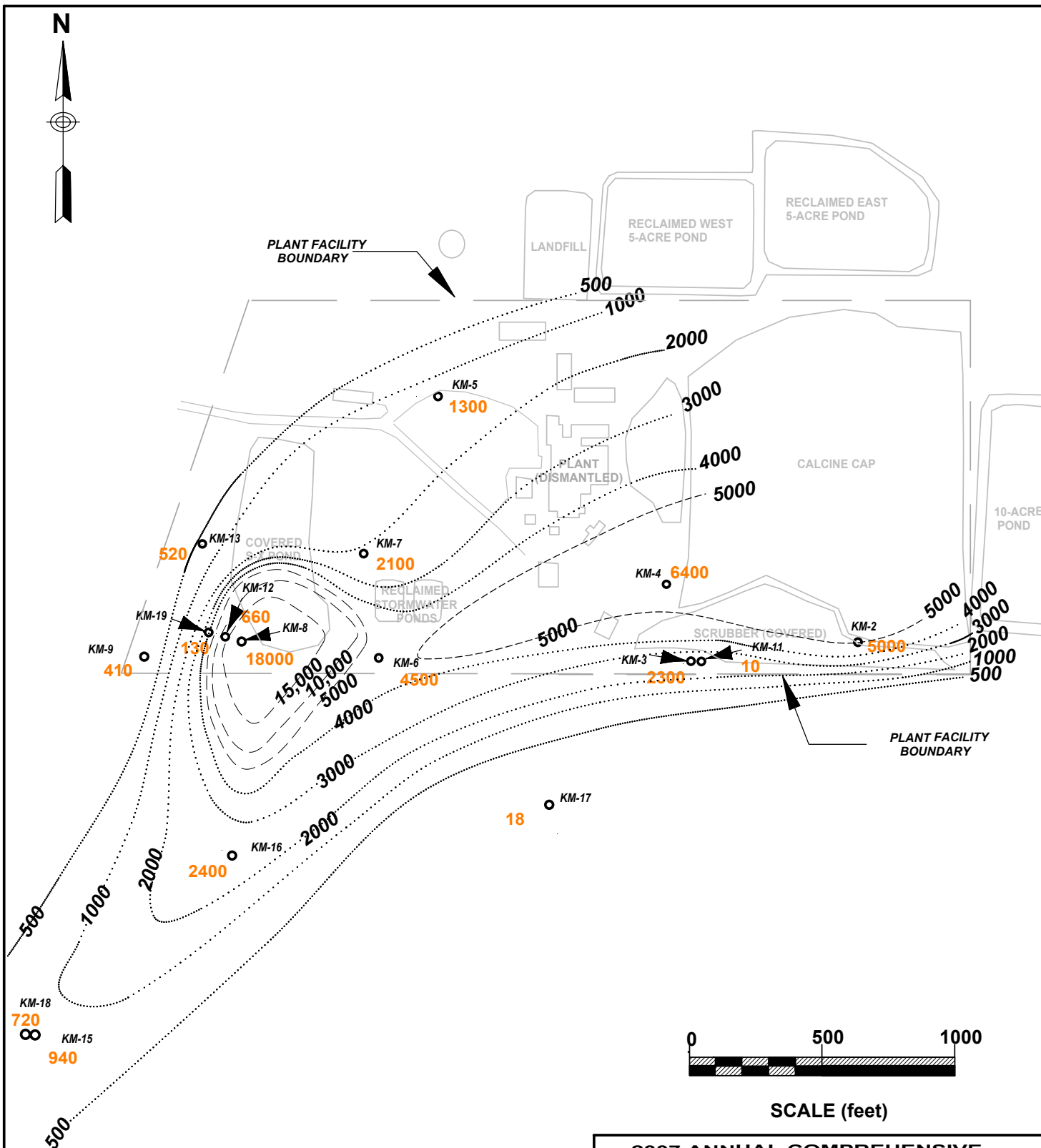
NOTE: CONCENTRATIONS ARE IN ug/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.
RBC FOR MOLYBDENUM IS 180 ug/l.

2007 ANNUAL COMPREHENSIVE
GROUND WATER REPORT

CONCENTRATIONS OF MOLYBDENUM IN GROUND WATER MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-8



NOTE: CONCENTRATIONS ARE IN ug/l.
CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS
IN SHALLOW AQUIFER.

RBC FOR VANADIUM IS 260 ug/l .

2007 ANNUAL COMPREHENSIVE GROUND WATER REPORT

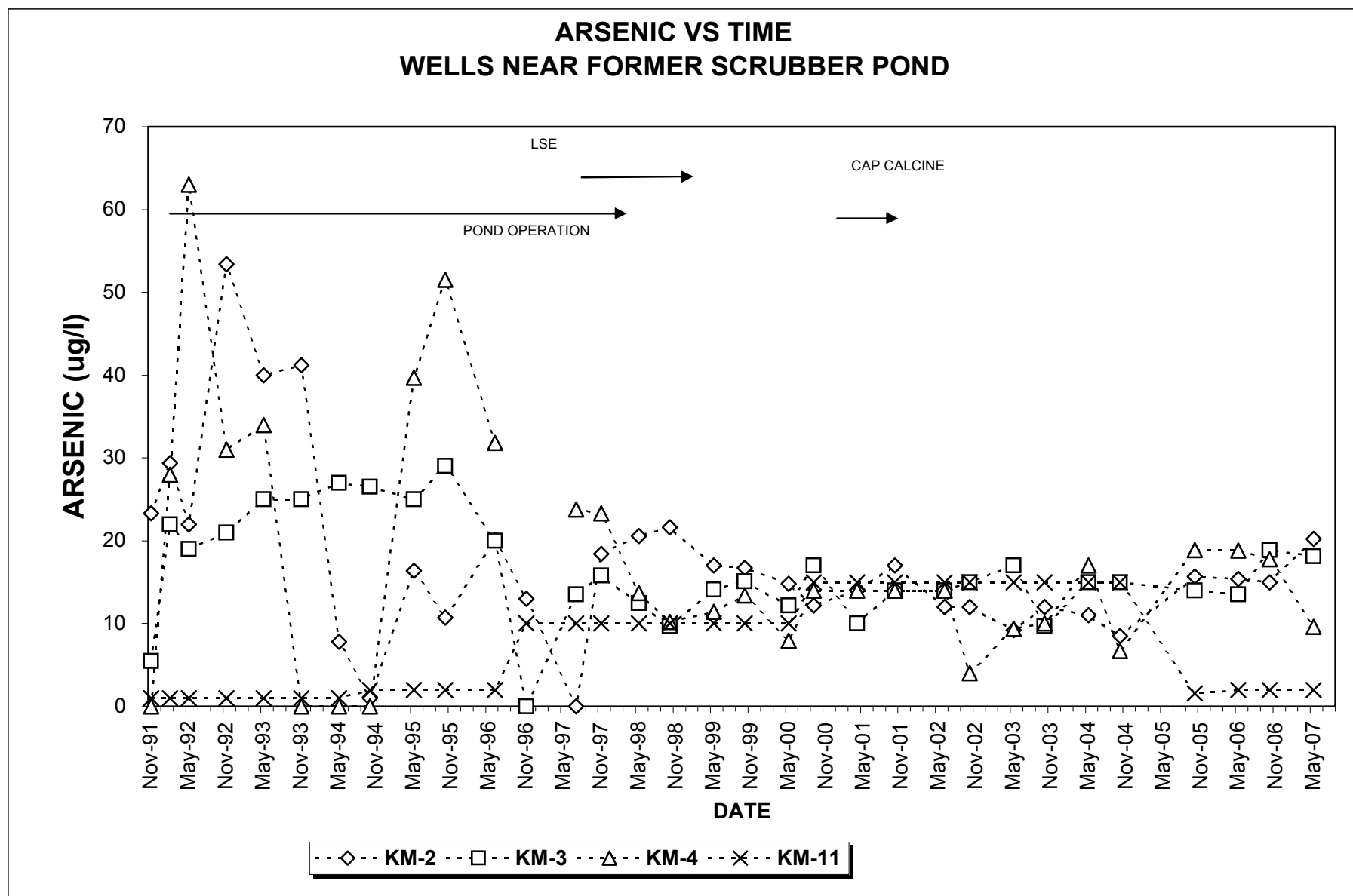
CONCENTRATIONS OF VANADIUM IN GROUND WATER MAY 2007

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-9

APPENDIX A

**GRAPHS OF GROUND AND SURFACE WATER
QUALITY VERSUS TIME**

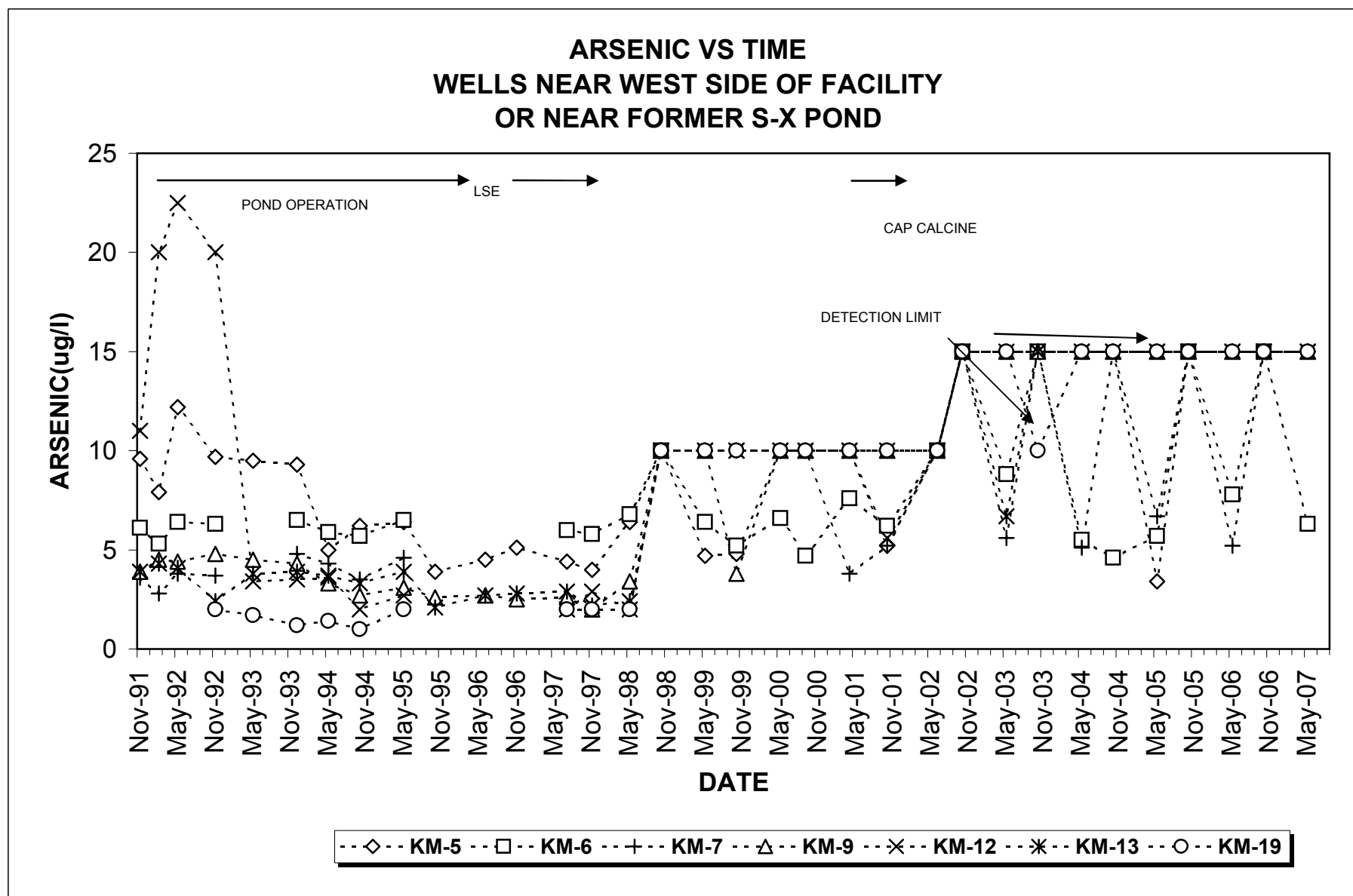


RBC FOR ARSENIC IS 50 $\mu\text{g/l}$

KM-2, KM-3, KM-11 ARE POC WELLS

VALUES LESS THAN DETECTION ARE PLOTTED AT DETECTION LIMIT

ARSENIC DETECTION LIMIT AT 10 to 15 $\mu\text{g/L}$ 1999 THROUGH 2007

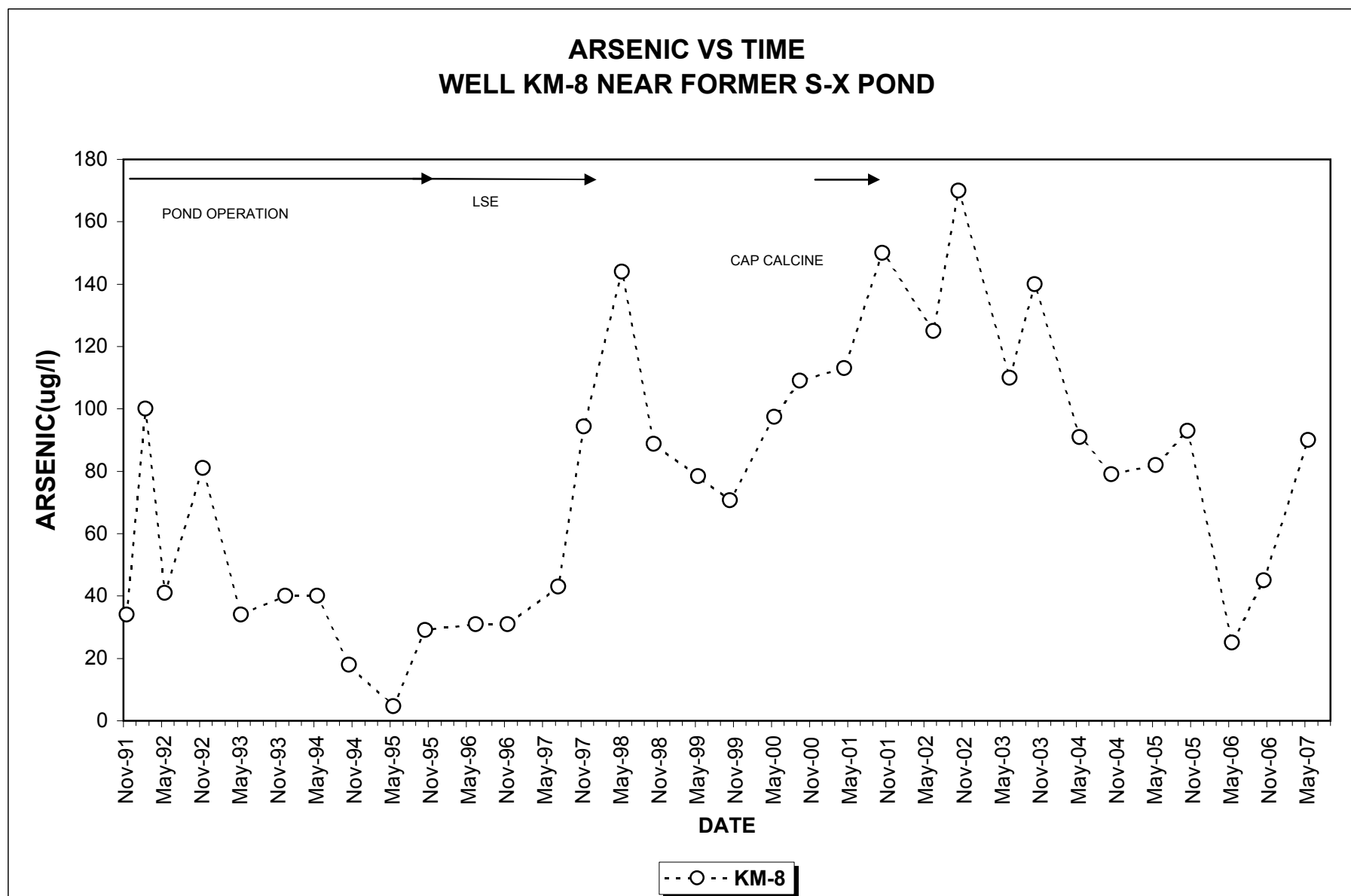


RBC FOR ARSENIC IS 50 ug/l

KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

VALUES LESS THAN DETECTION ARE PLOTTED AT THE DETECTION LIMIT

ARSENIC IS LESS THAN DETECTION OR REPORTING LIMIT IN ALL WELLS DURING 2003 through 2007

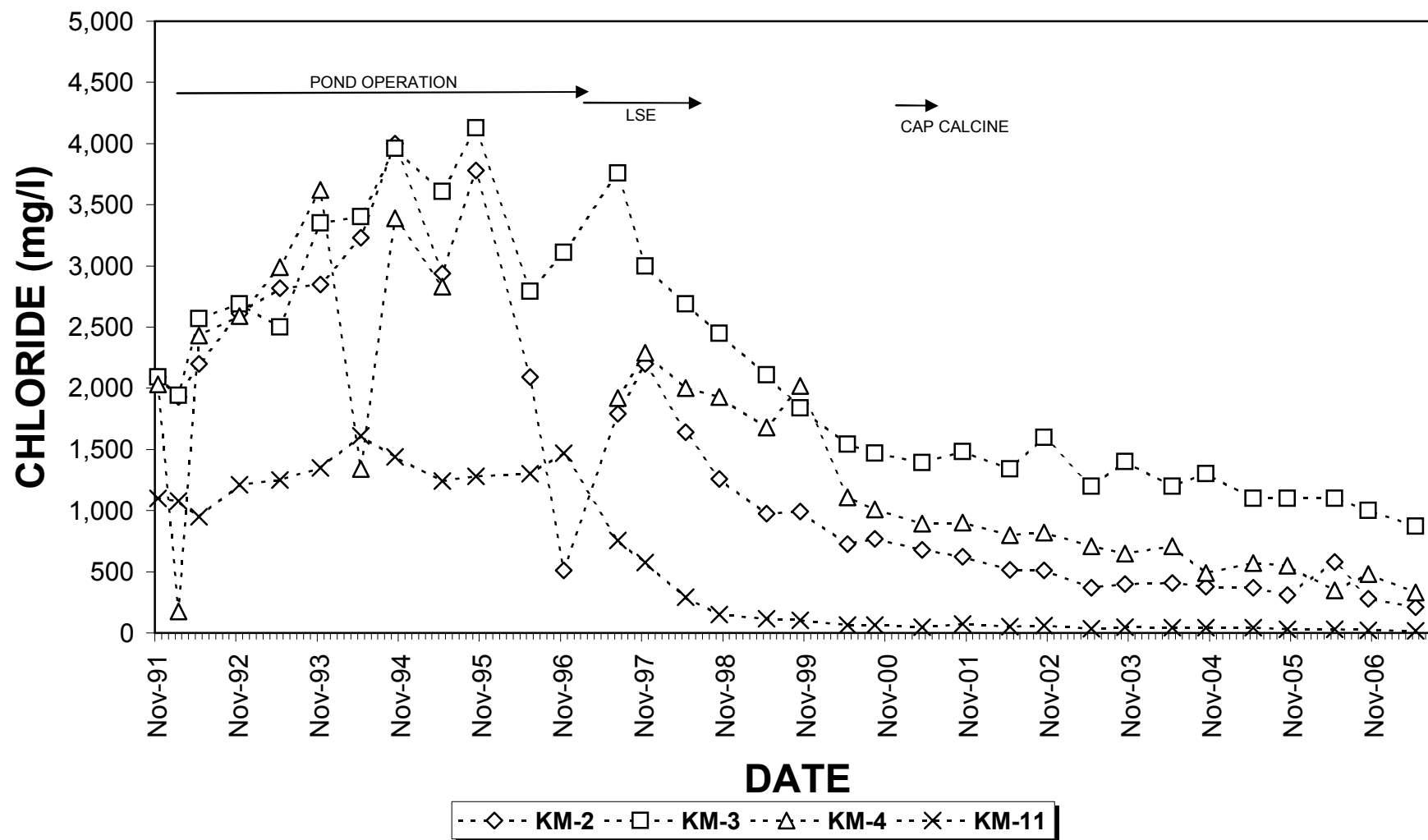


RBC FOR ARSENIC IS 50 ug/l

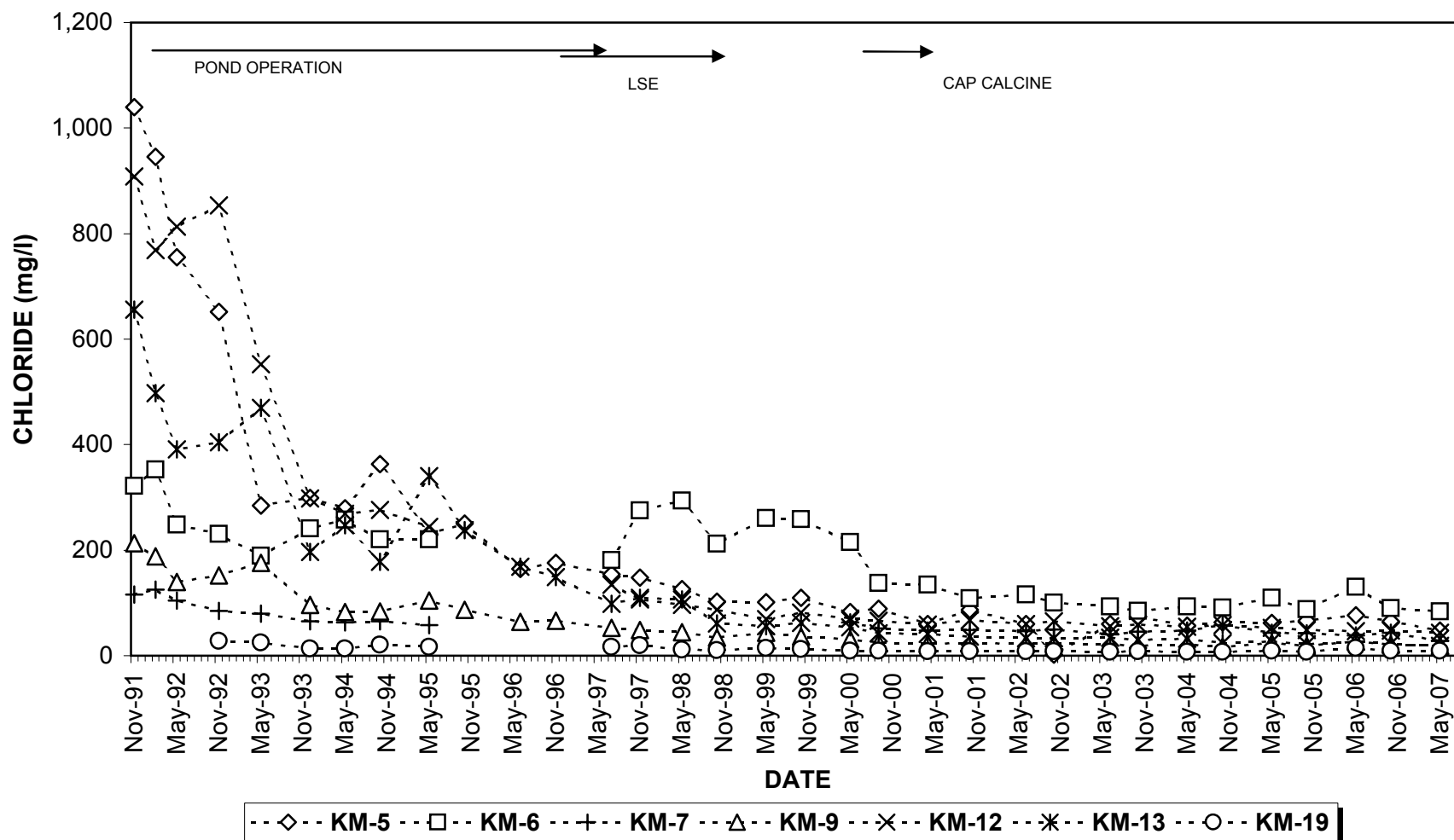
KM-8 IS A POC WELL

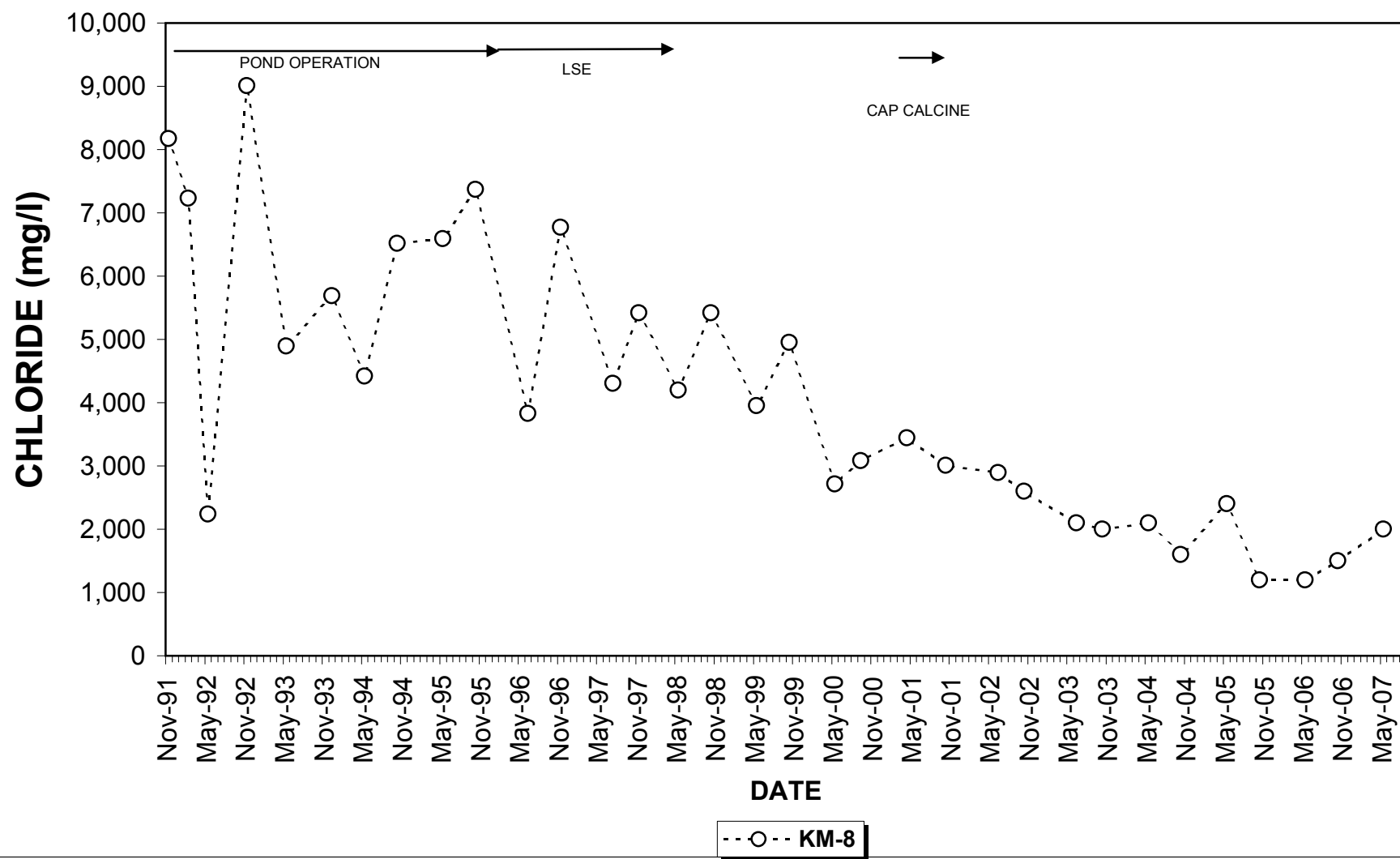
VALUES LESS THAN DETECTION ARE PLOTTED AT THE DETECTION LIMIT

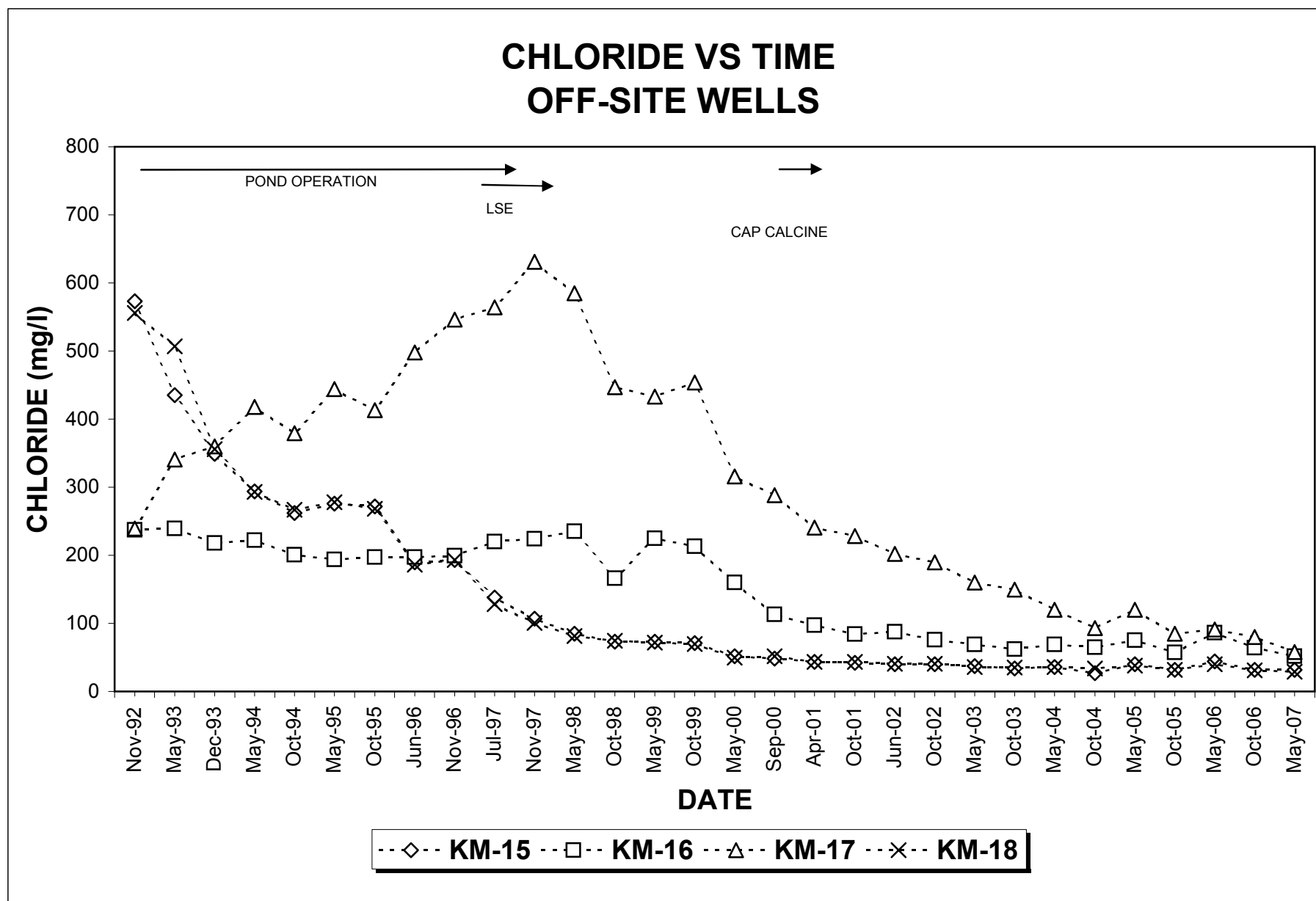
CHLORIDE VS TIME WELLS NEAR FORMER SCRUBBER POND

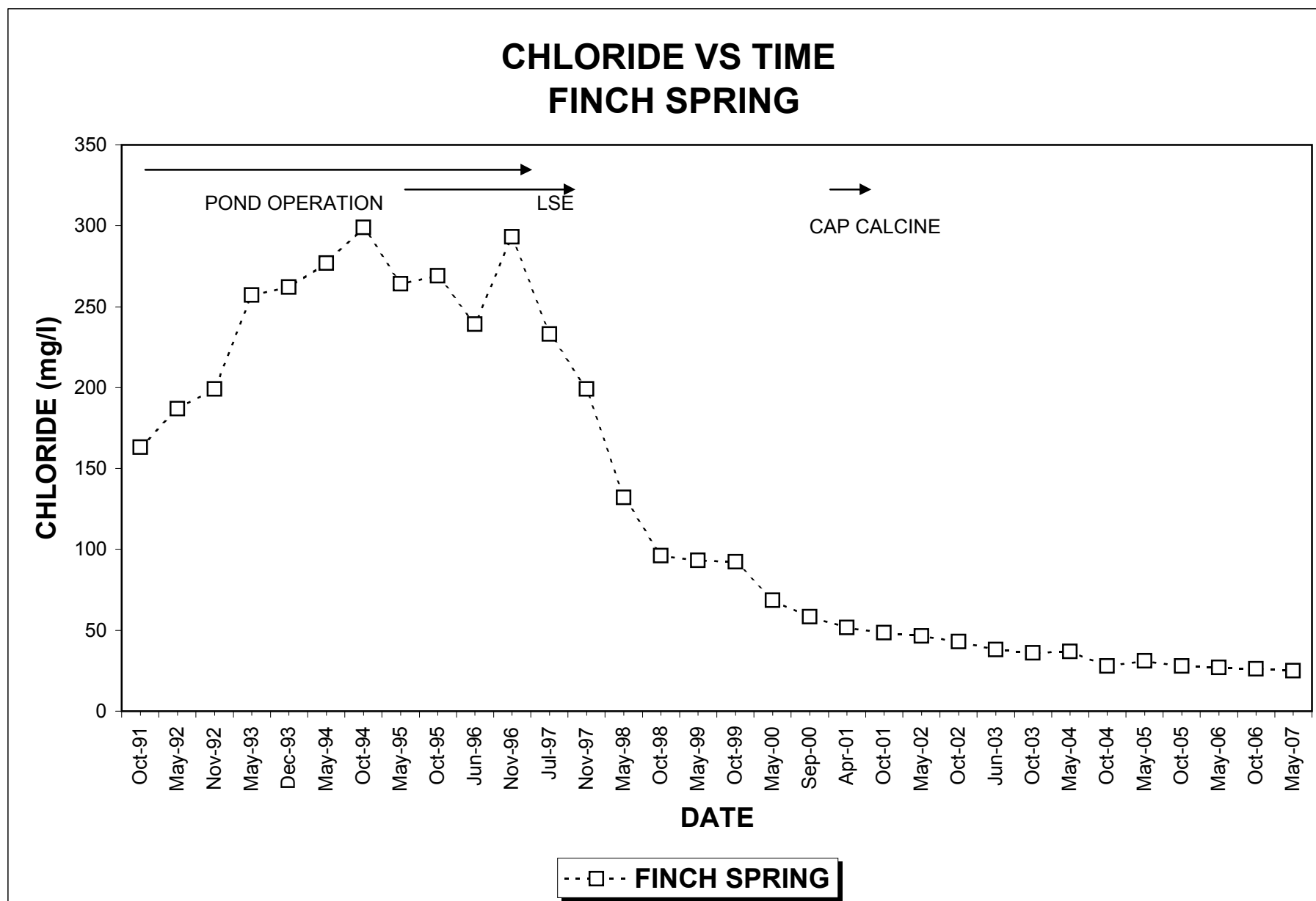


CHLORIDE VS TIME WELLS NEAR WEST SIDE OF FACILITY OR NEAR FORMER S-X POND

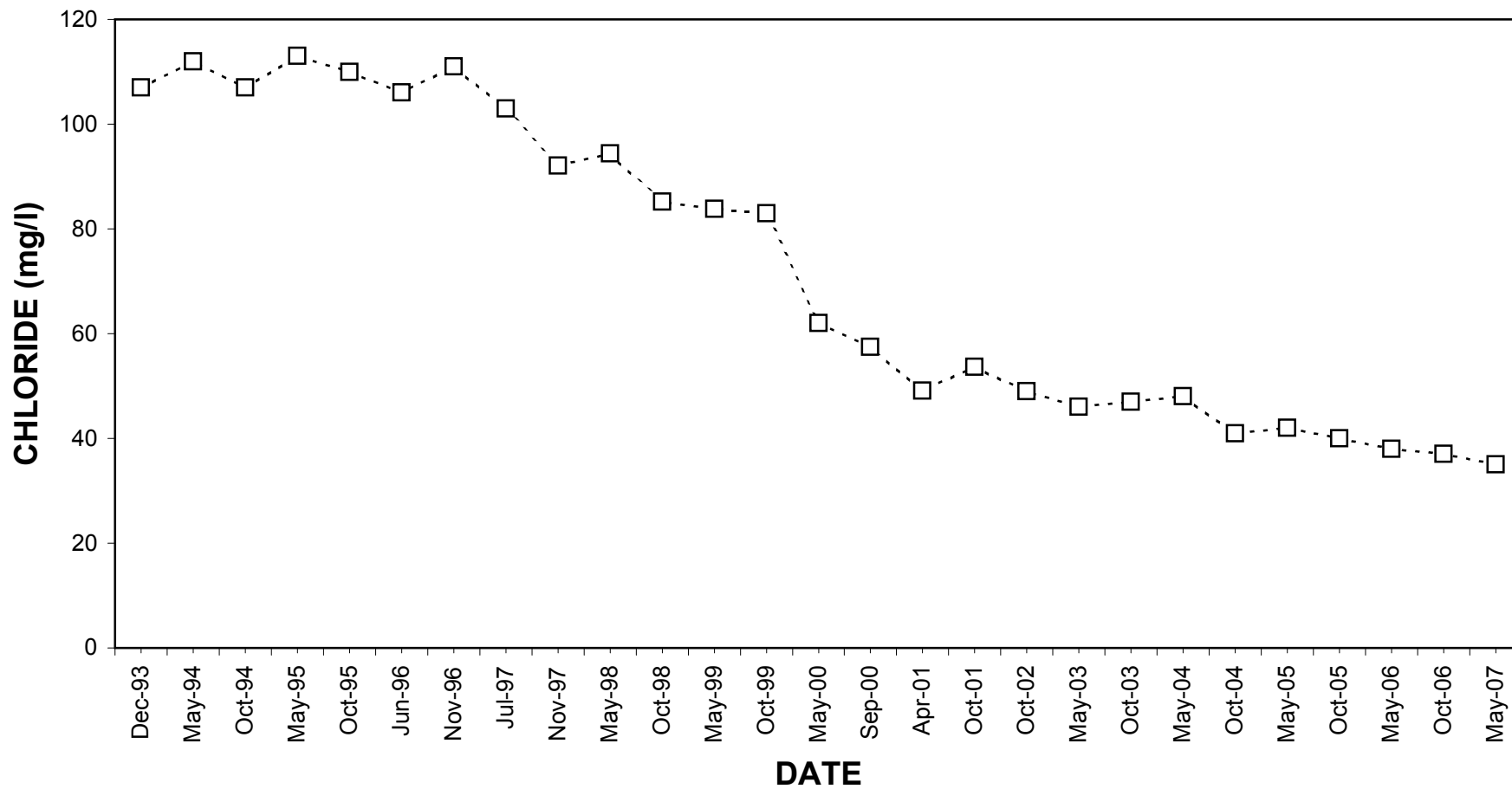


**CHLORIDE VS TIME
WELL KM-8 NEAR FORMER S-X POND**



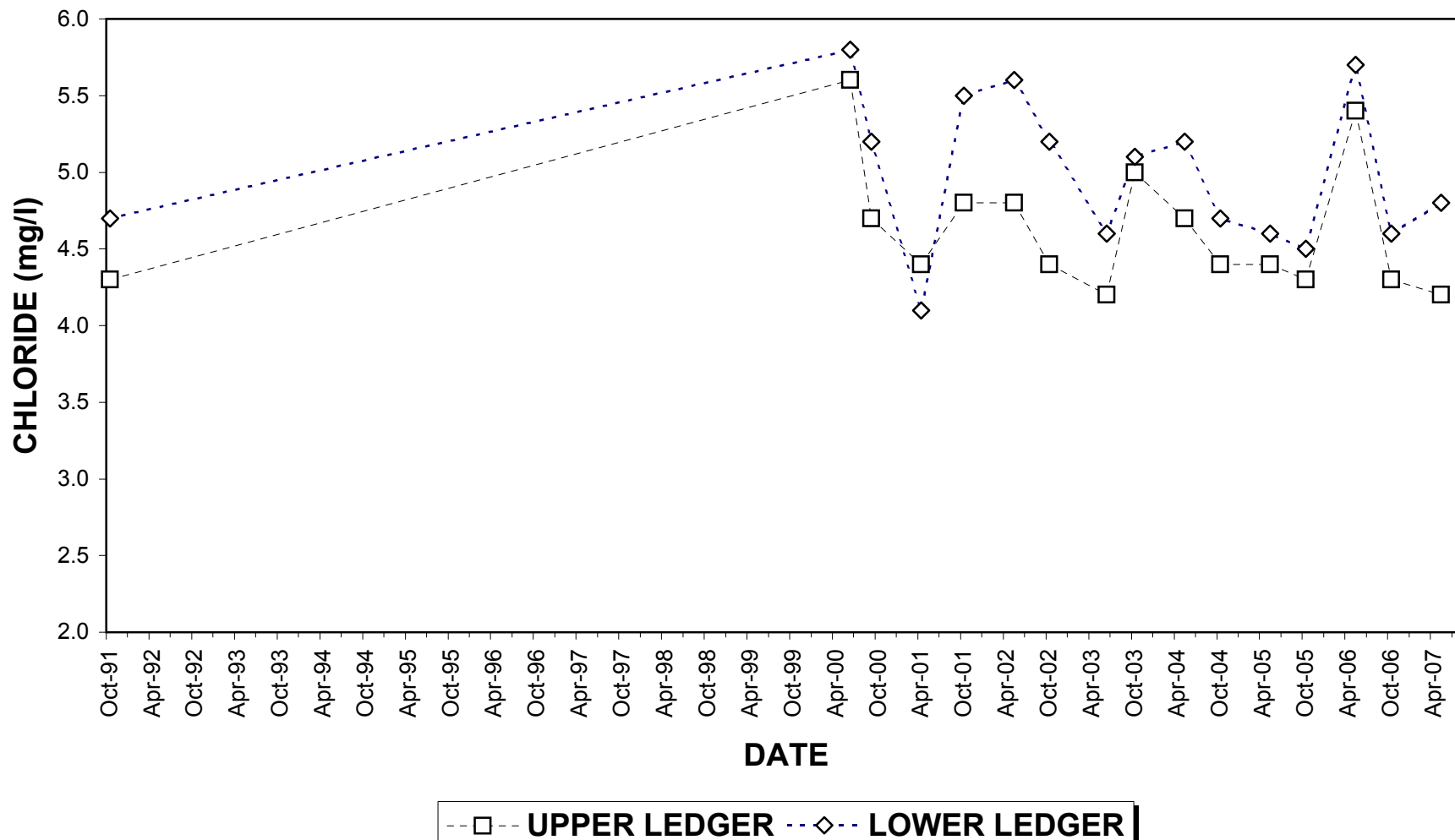


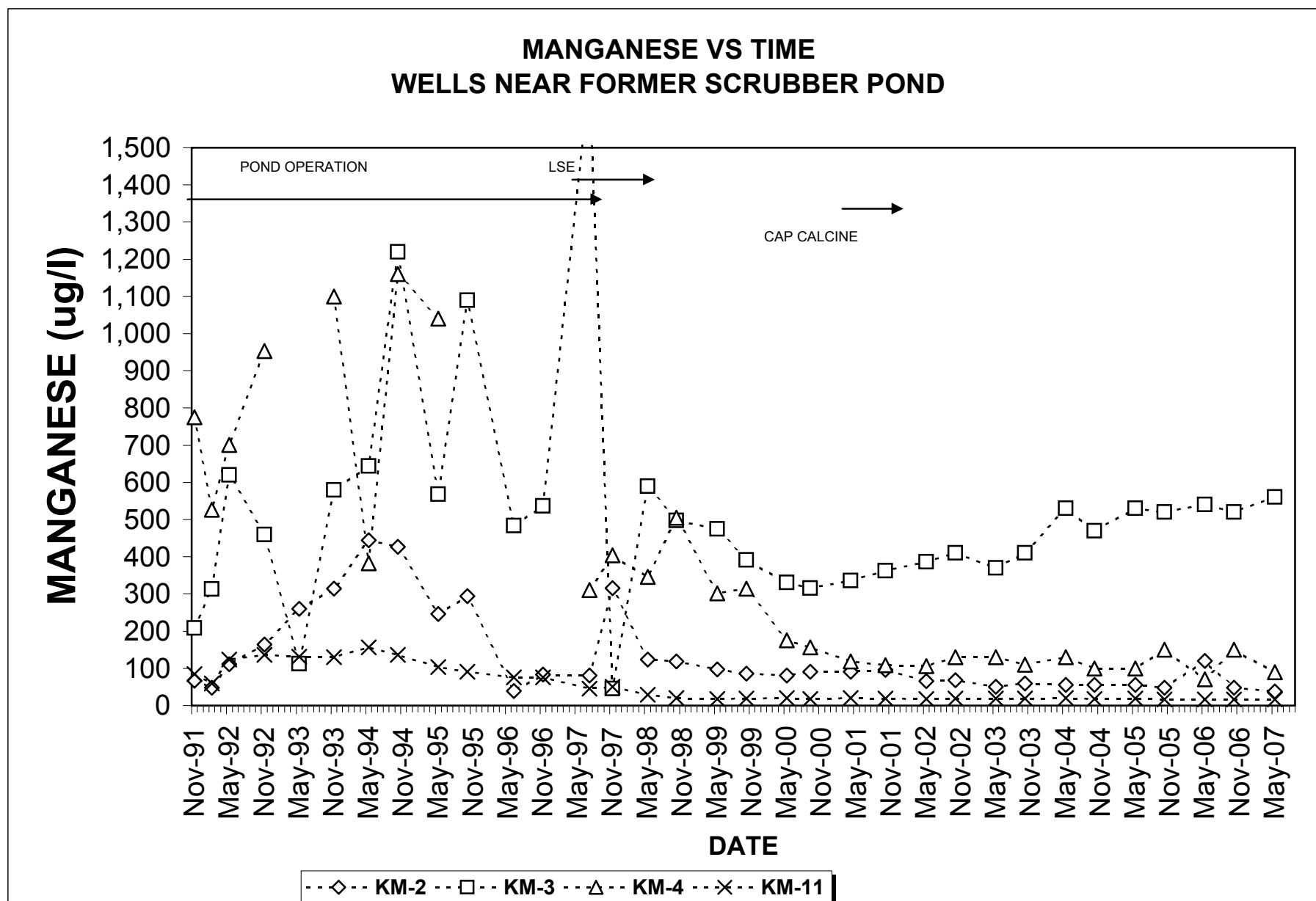
CHLORIDE VS TIME BIG SPRING



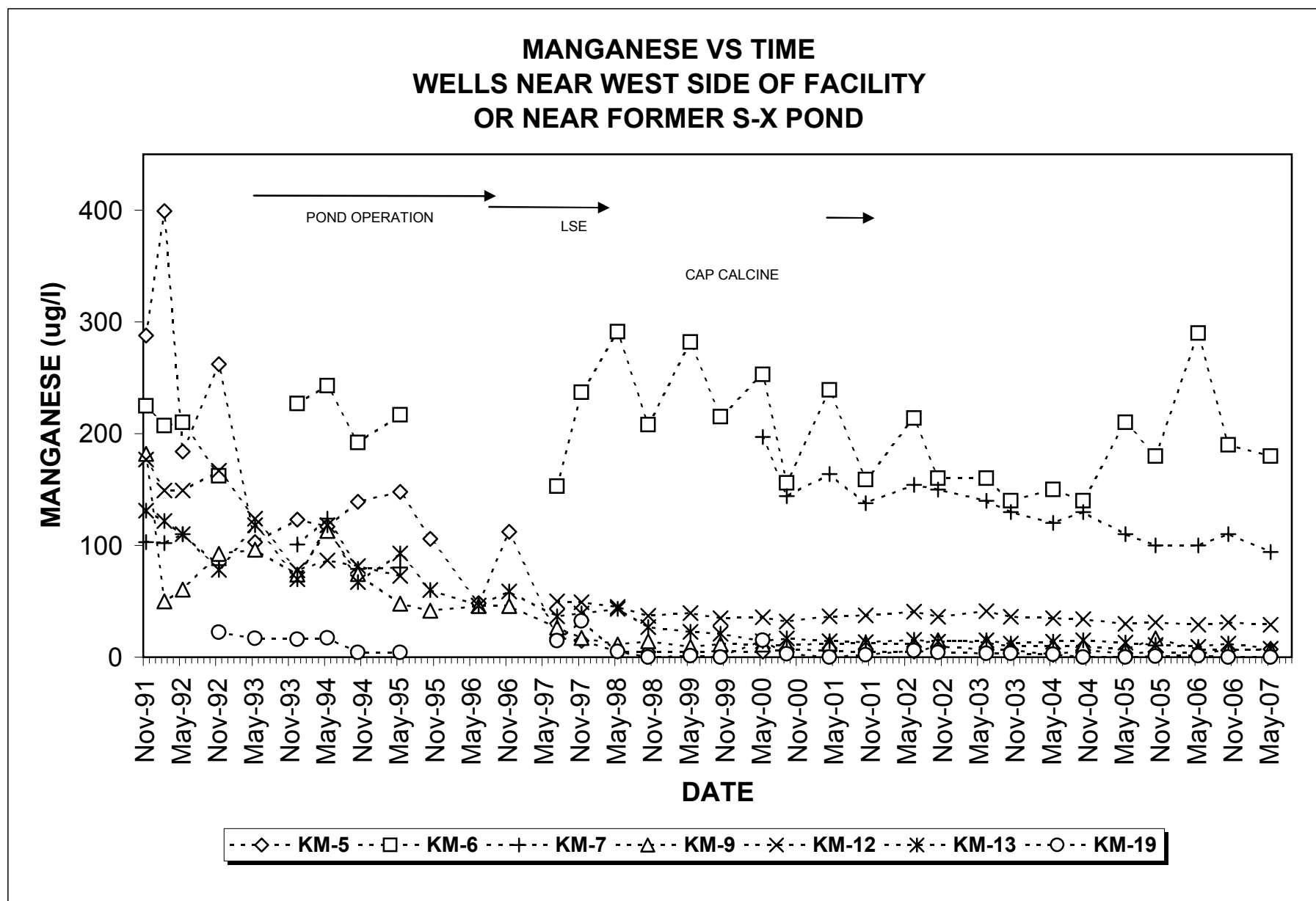
---□--- **BIG SPRING**

CHLORIDE VS TIME UPPER AND LOWER LEDGER SPRINGS



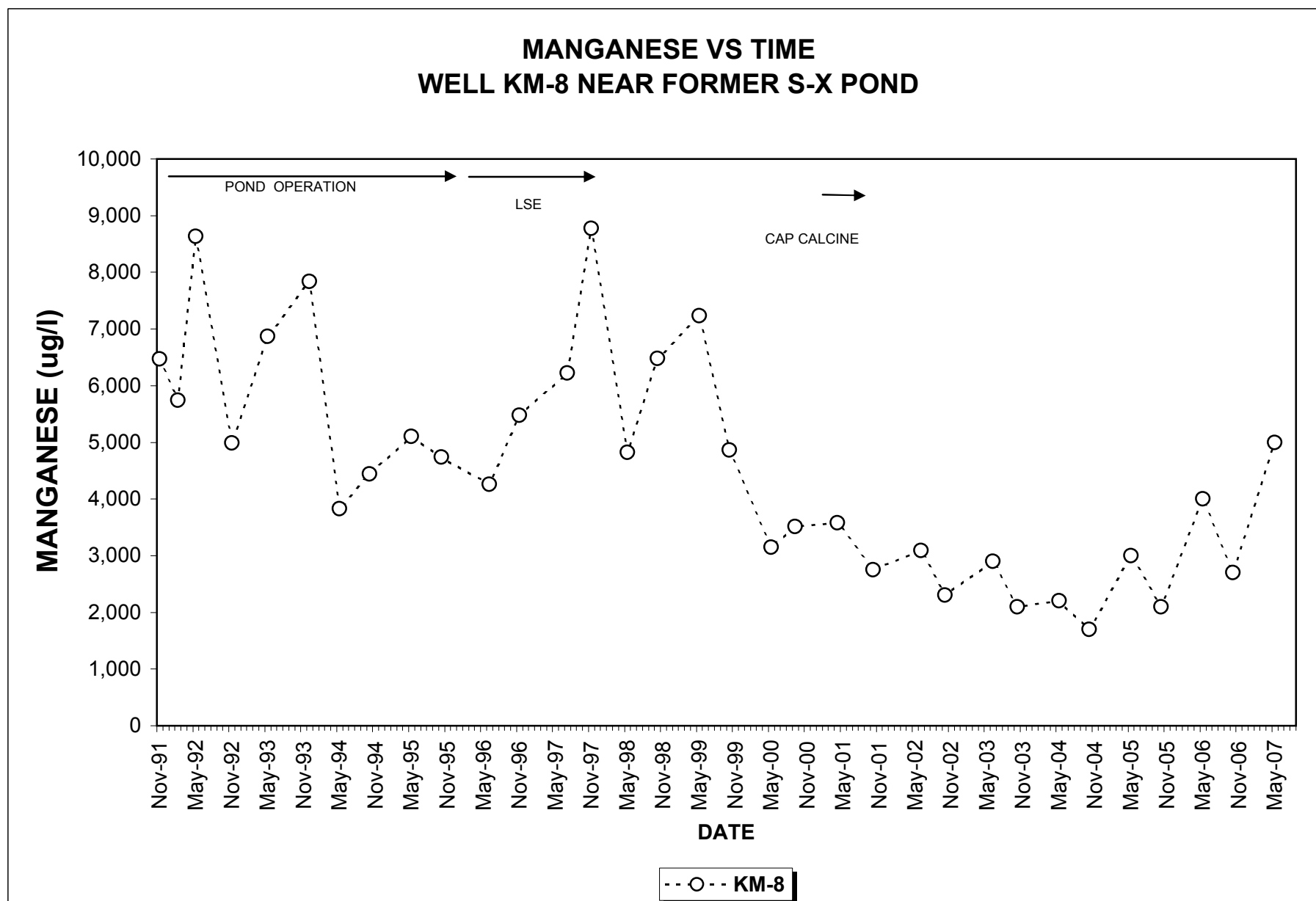


RBC FOR MANGANESE IS 180 ug/l
KM-2, KM-3, KM-11 ARE POC WELLS

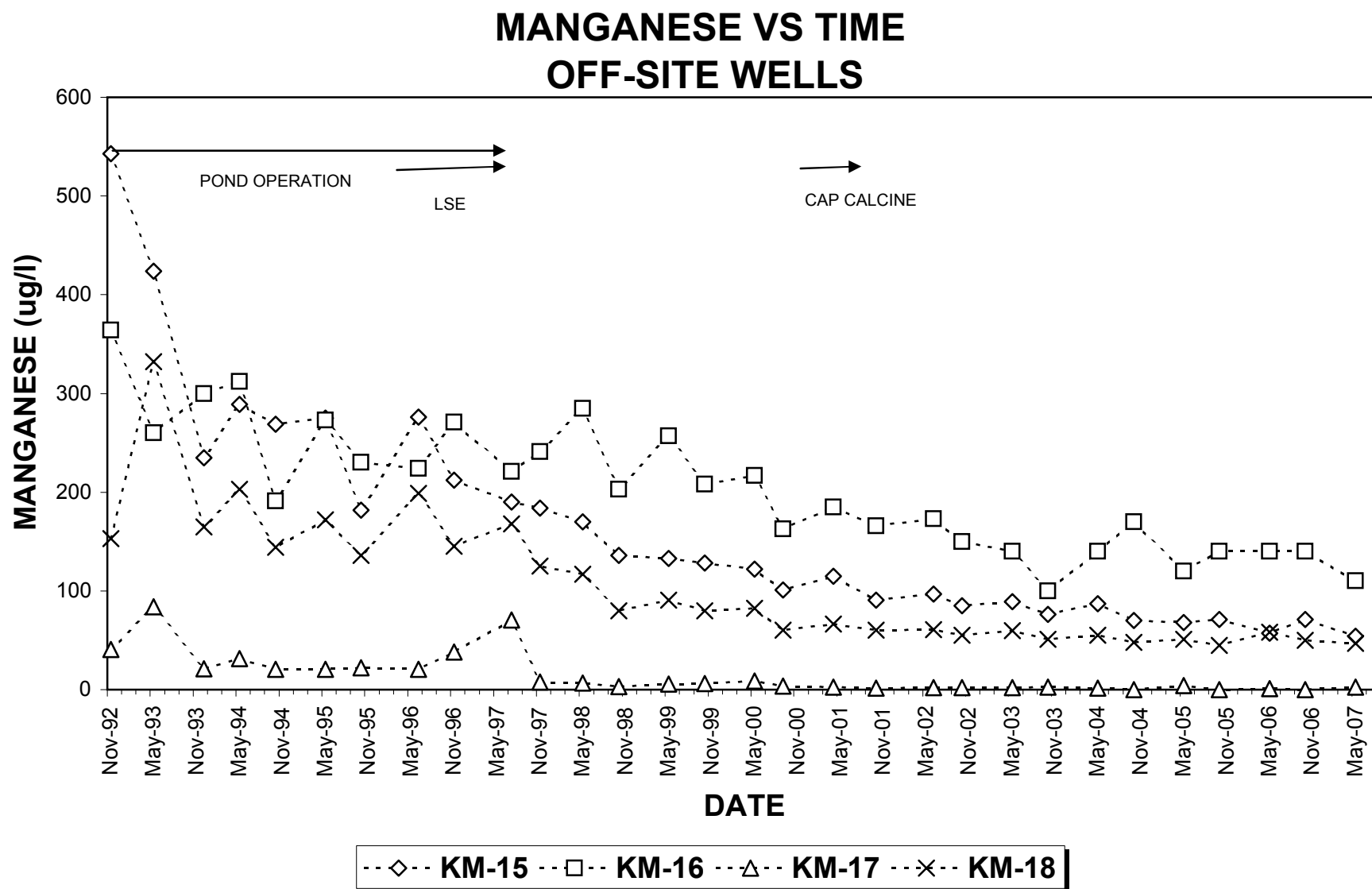


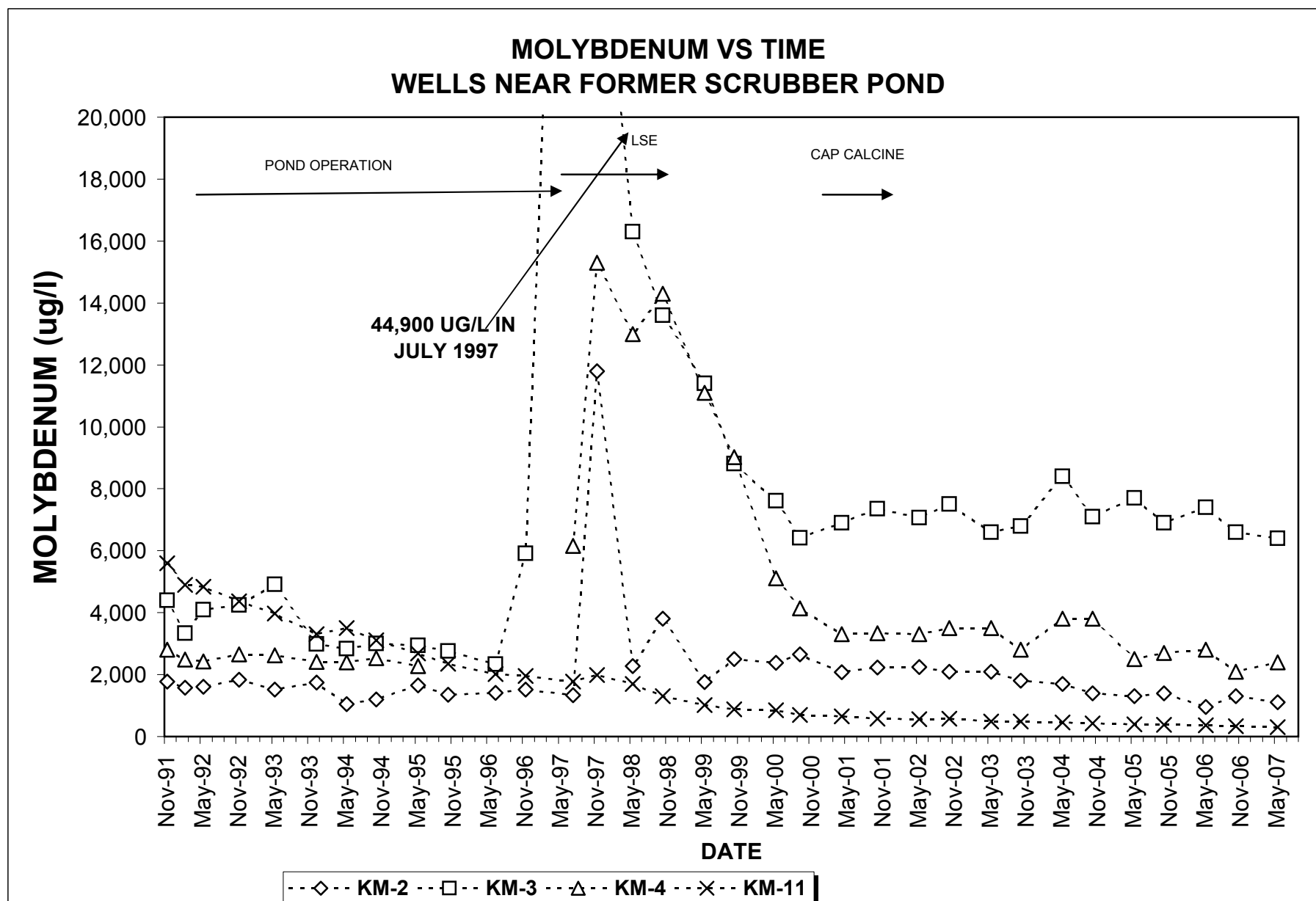
RBC FOR MANGANESE IS 180 ug/l

KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

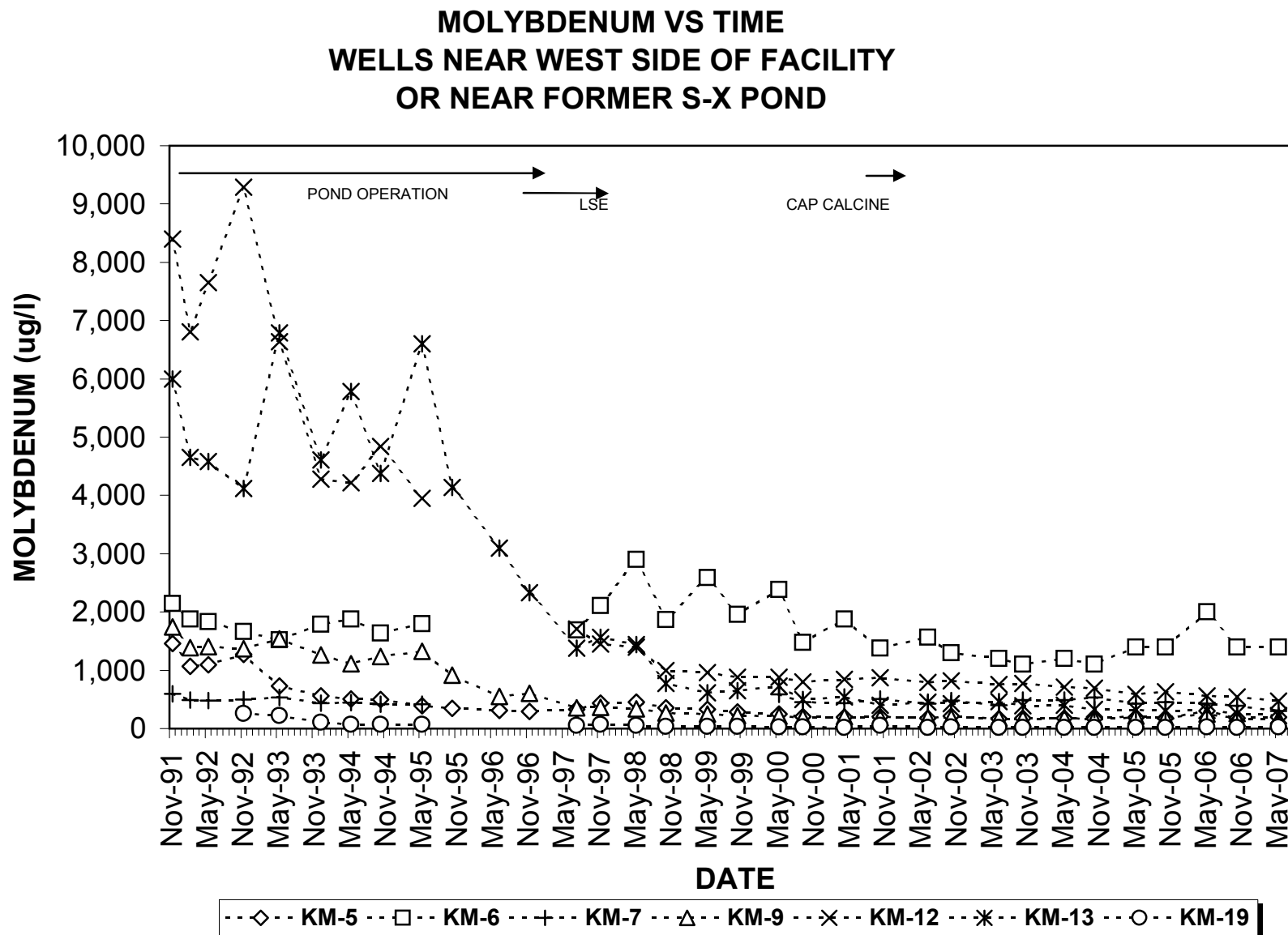


RBC FOR MANGANESE IS 180 ug/l
KM-8 IS A POC WELL



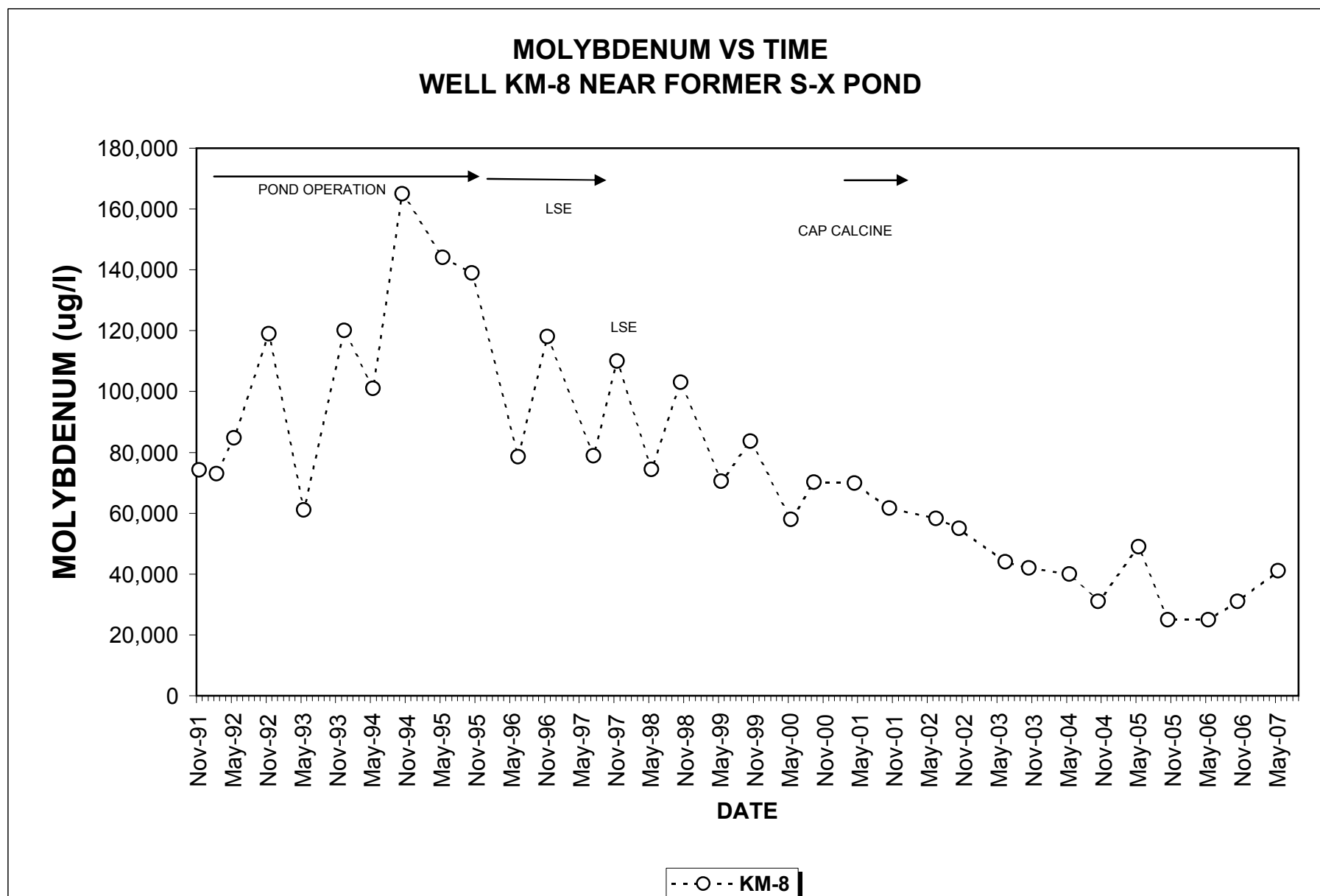


RBC FOR MOLYBDENUM IS 180 ug/l
KM-2, KM-3, KM-11 ARE POC WELLS



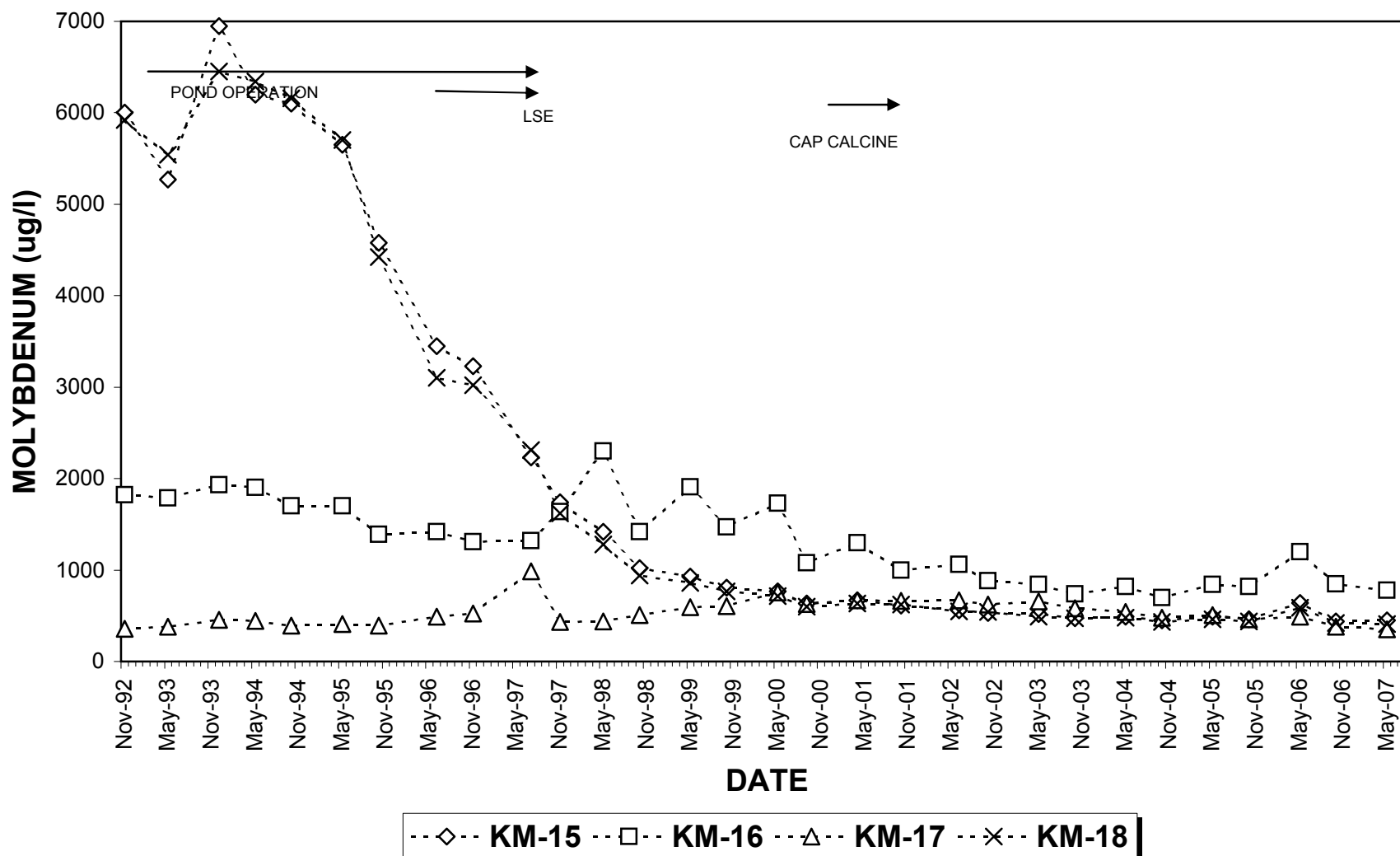
RBC FOR MOLYBDENUM IS 180 ug/l

KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

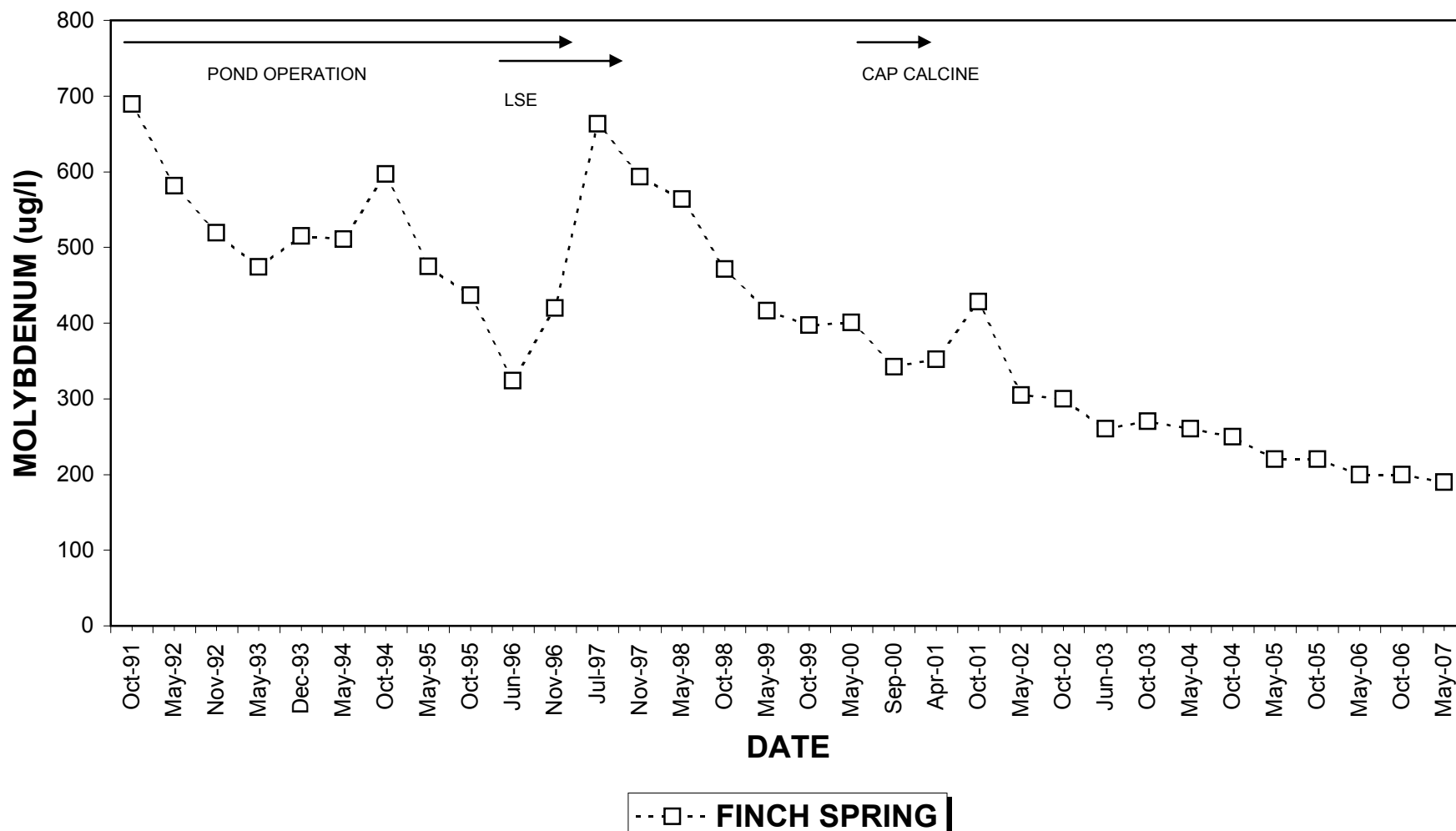


RBC FOR MOLYBDENUM IS 180 ug/l
KM-8 IS A POC WELL

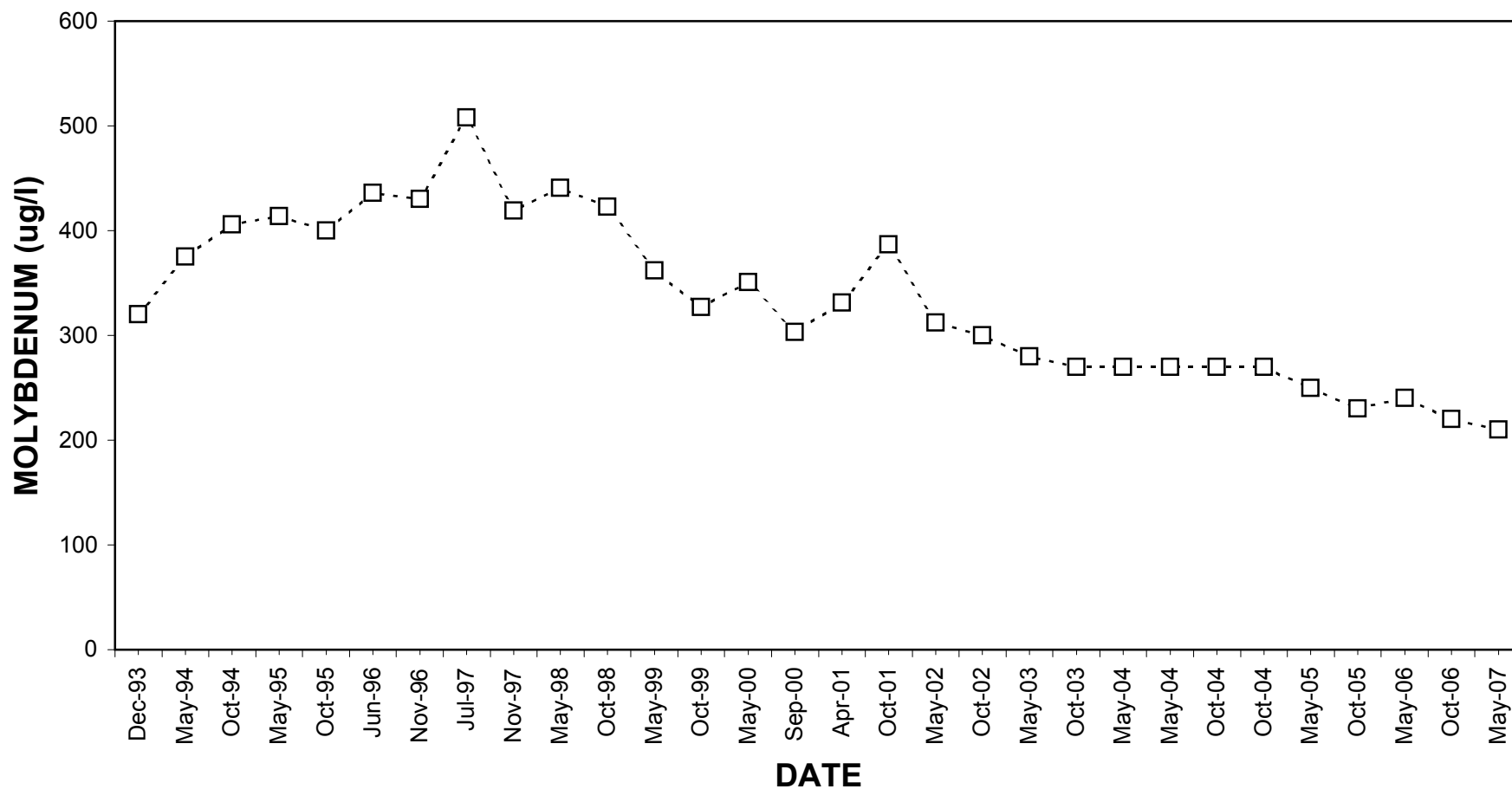
MOLYBDENUM VS TIME OFF-SITE WELLS



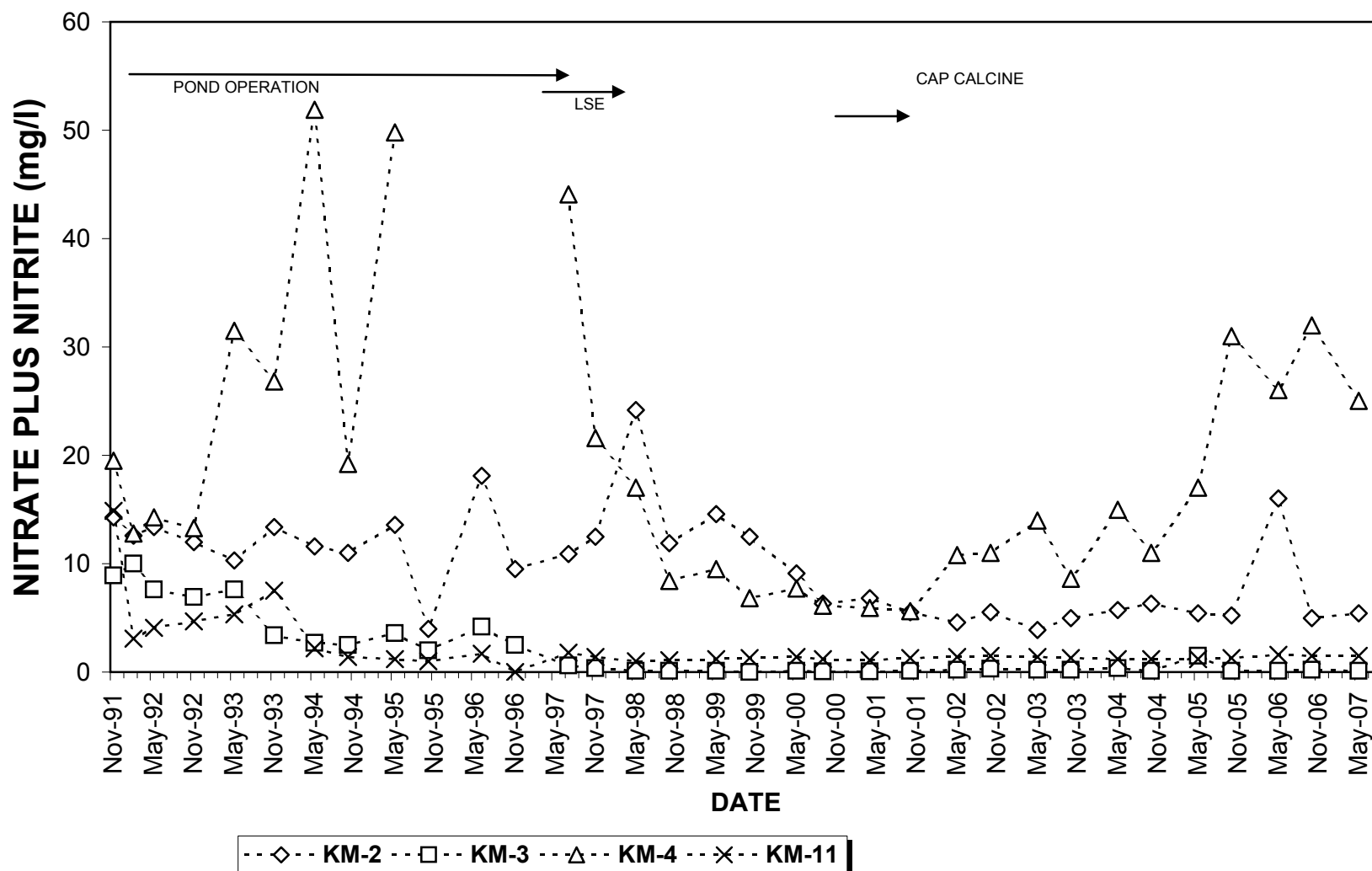
MOLYBDENUM VS TIME FINCH SPRING

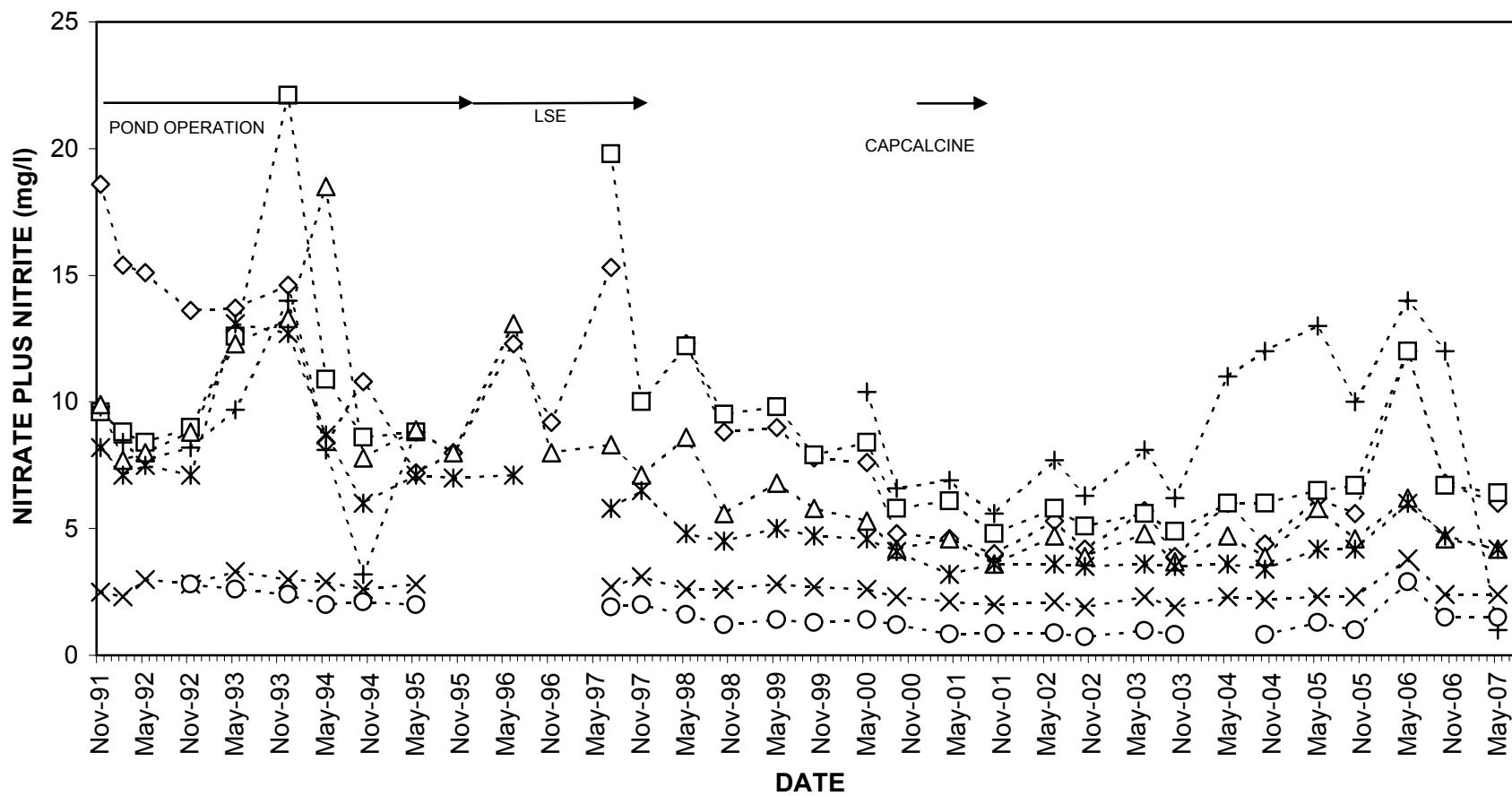


MOLYBDENUM VS TIME BIG SPRING

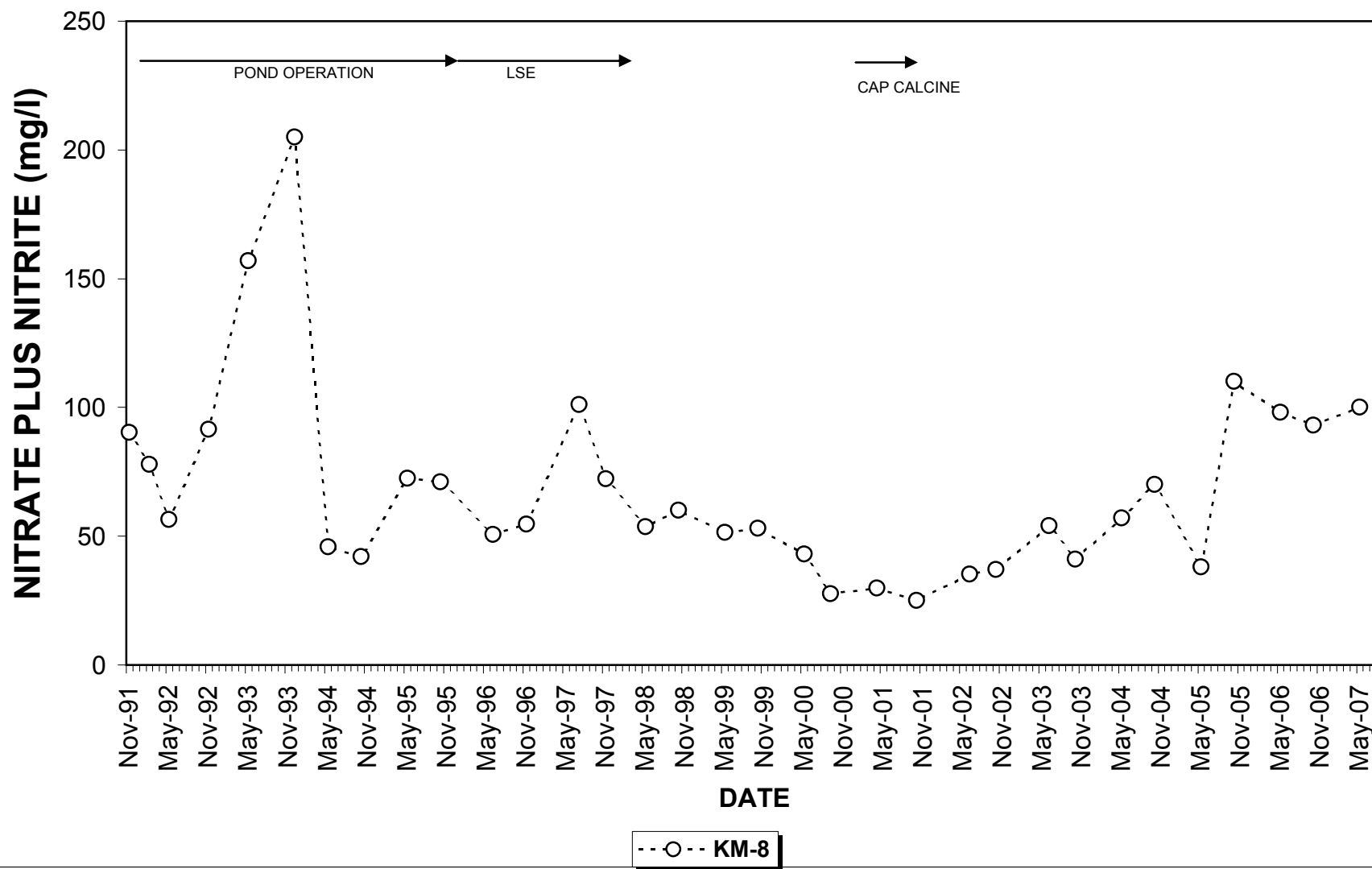


---□--- **BIG SPRING**

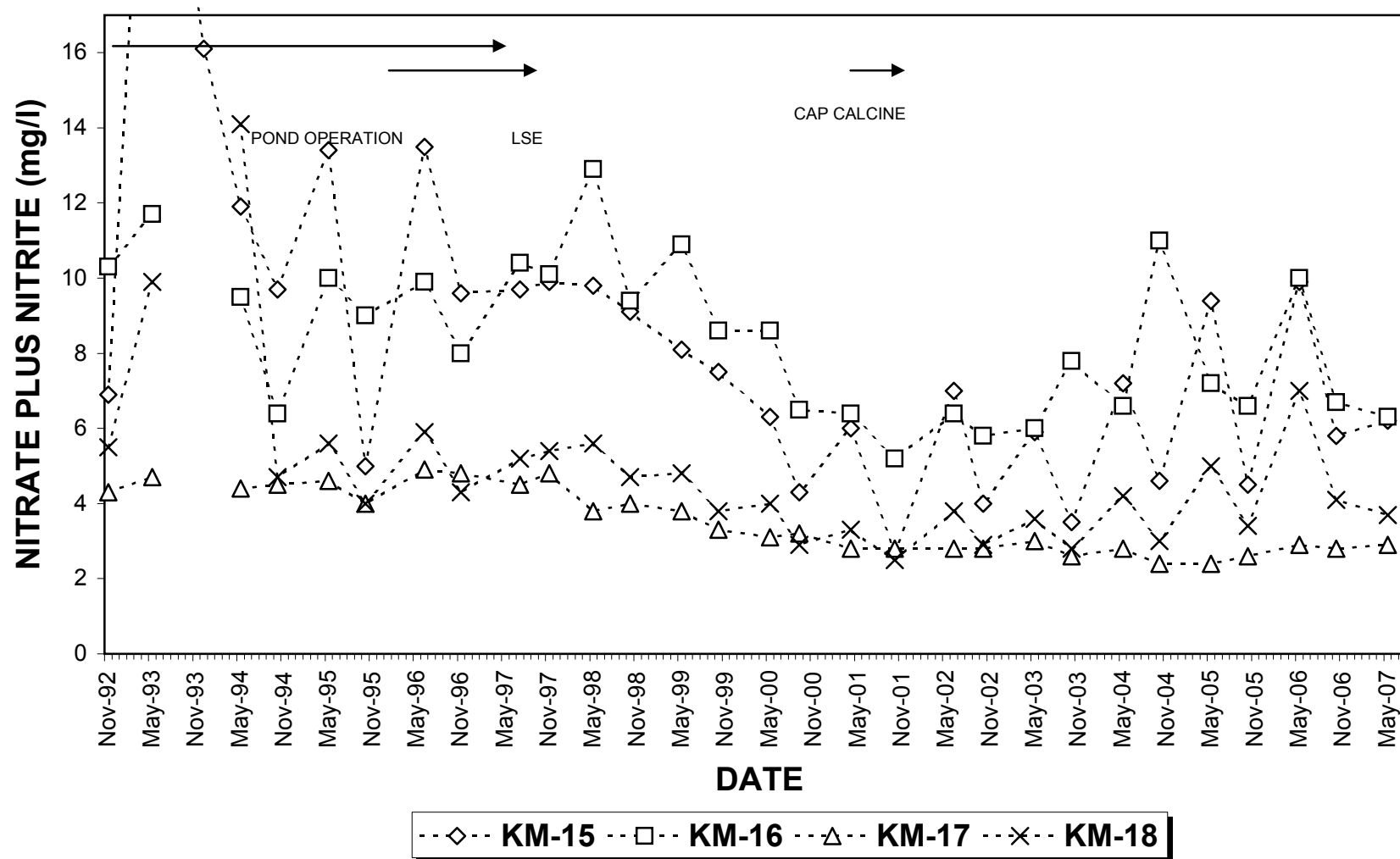
**NITRATE PLUS NITRITE VS TIME
WELLS NEAR FORMER SCRUBBER POND**

**NITRATE PLUS NITRITE VS TIME
WELLS NEAR WEST SIDE OF FACILITY
OR NEAR FORMER S-X POND**

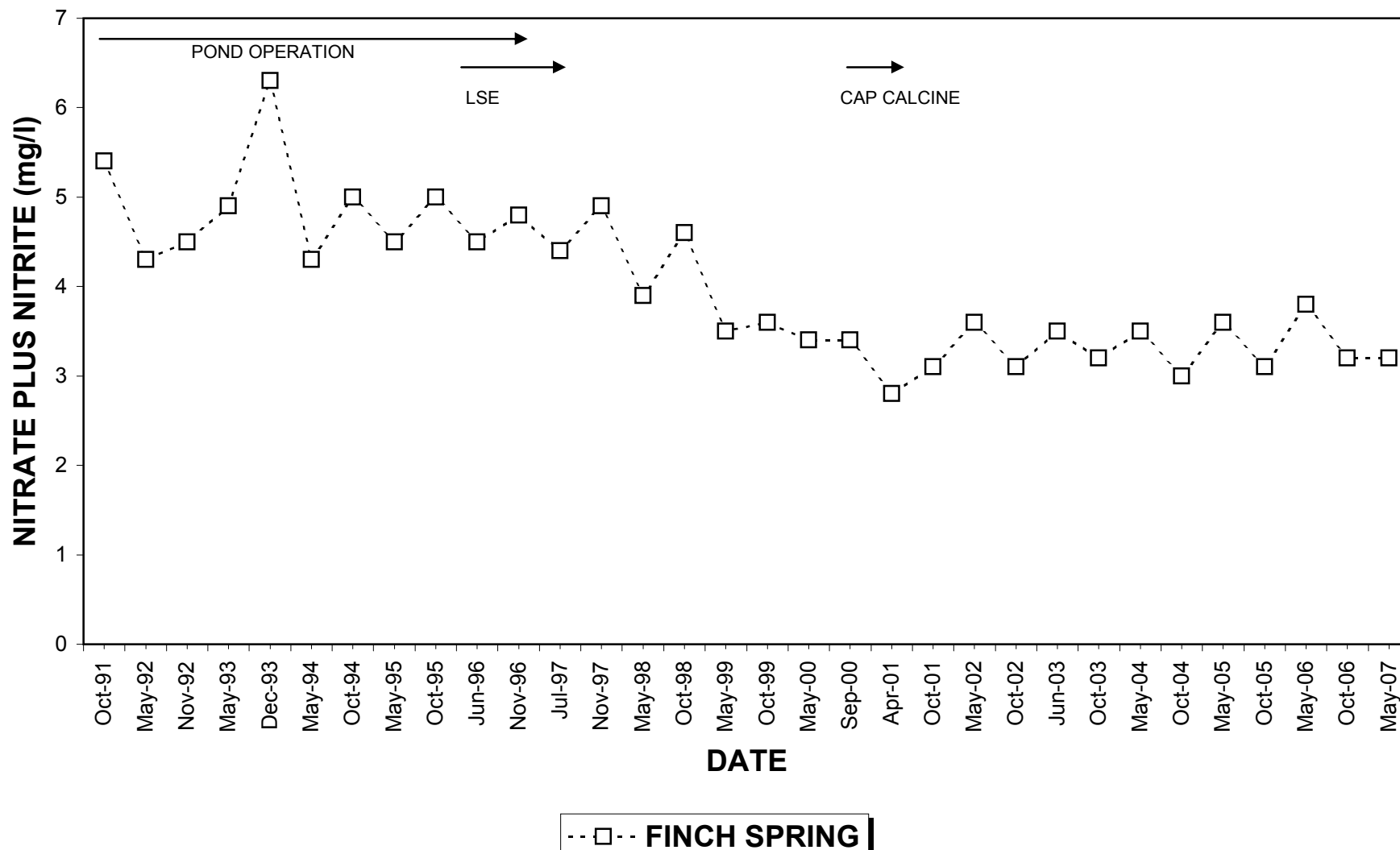
---◇--- KM-5 ---□--- KM-6 ---+--- KM-7 ---△--- KM-9 ---×--- KM-12 ---*--- KM-13 ---○--- KM-19

**NITRATE PLUS NITRITE VS TIME
WELL KM-8 NEAR FORMER S-X POND**

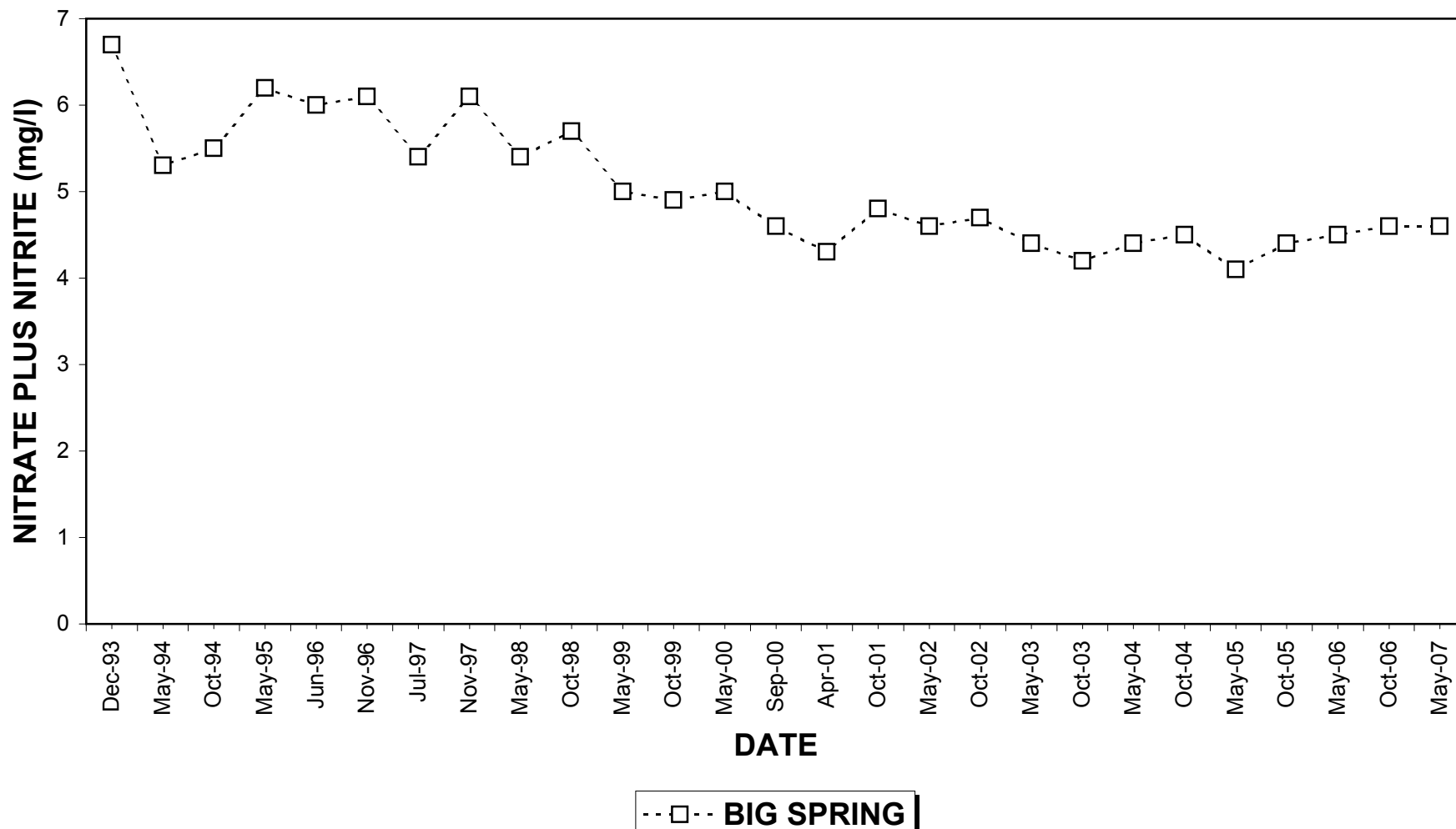
NITRATE PLUS NITRITE VS TIME OFF-SITE WELLS



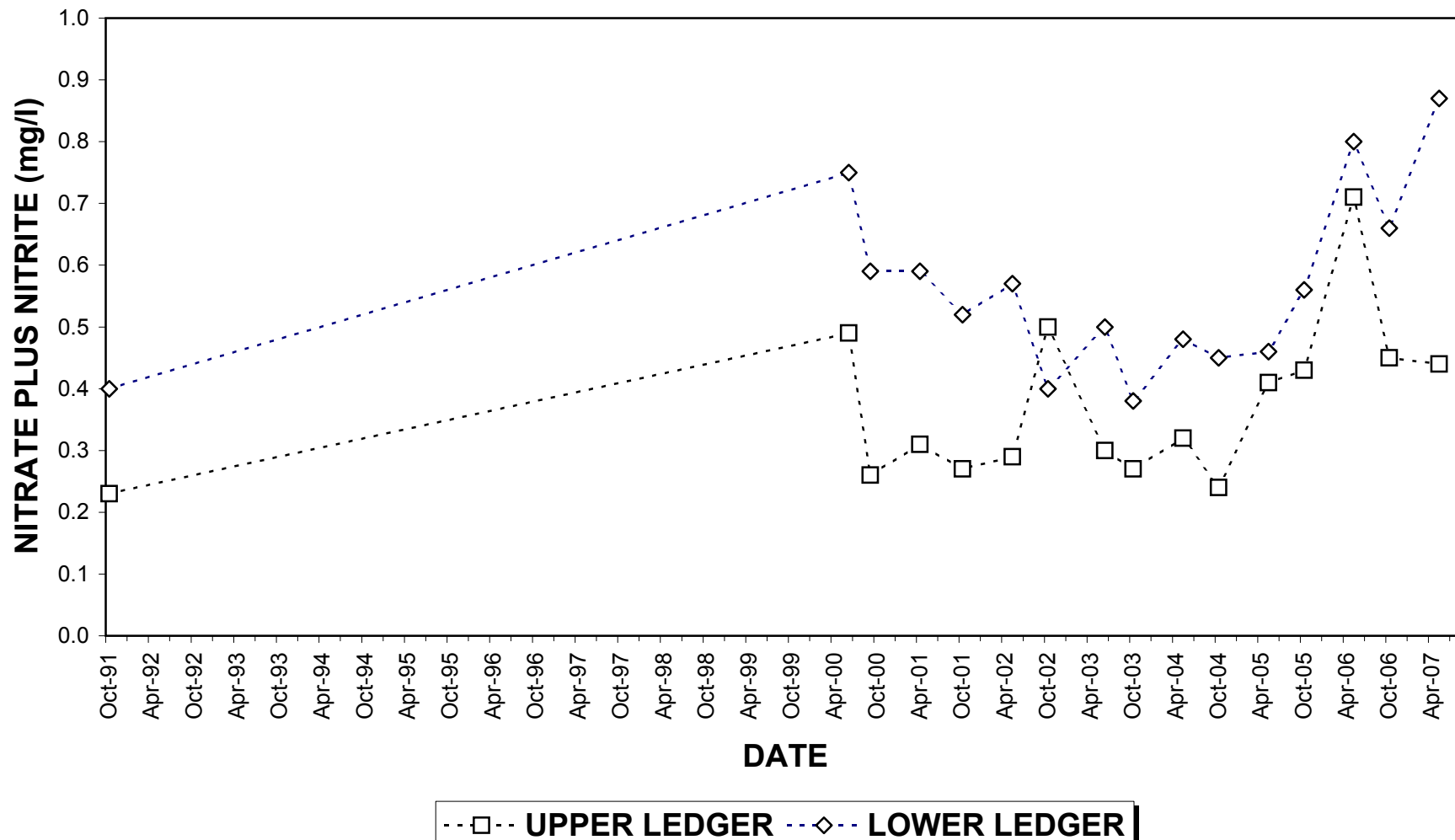
NITRATE PLUS NITRITE VS TIME FINCH SPRING

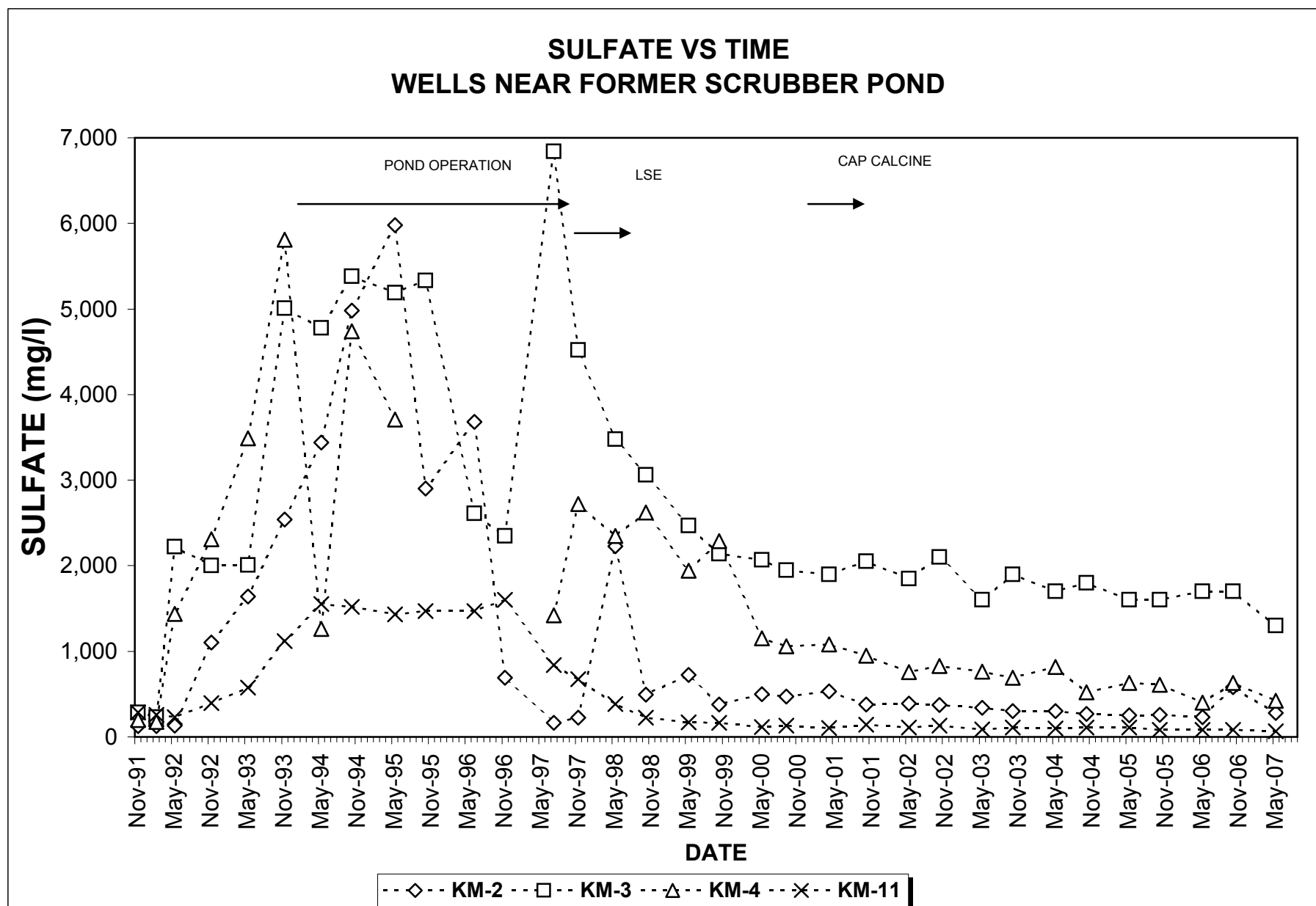


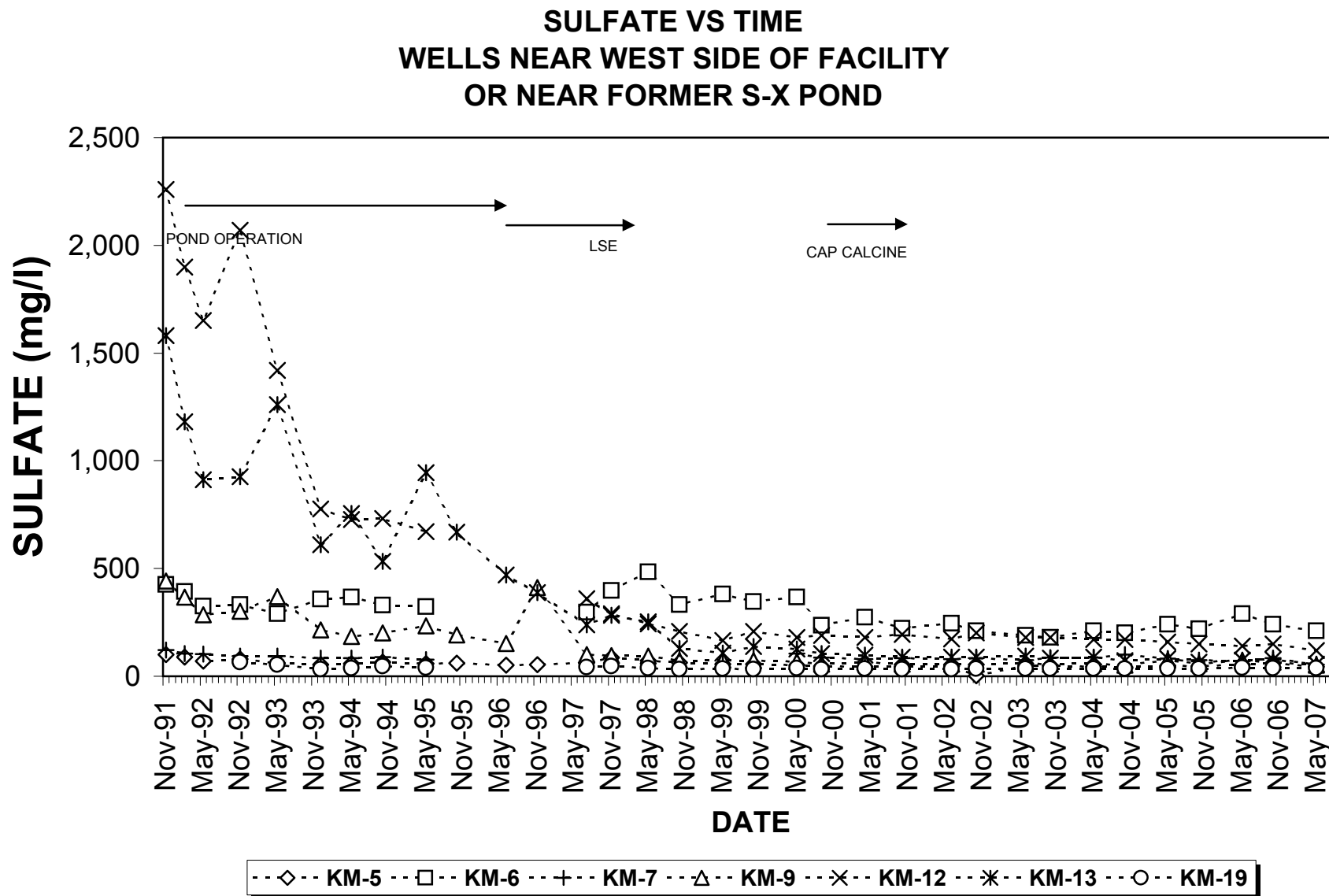
NITRATE PLUS NITRITE VS TIME BIG SPRING

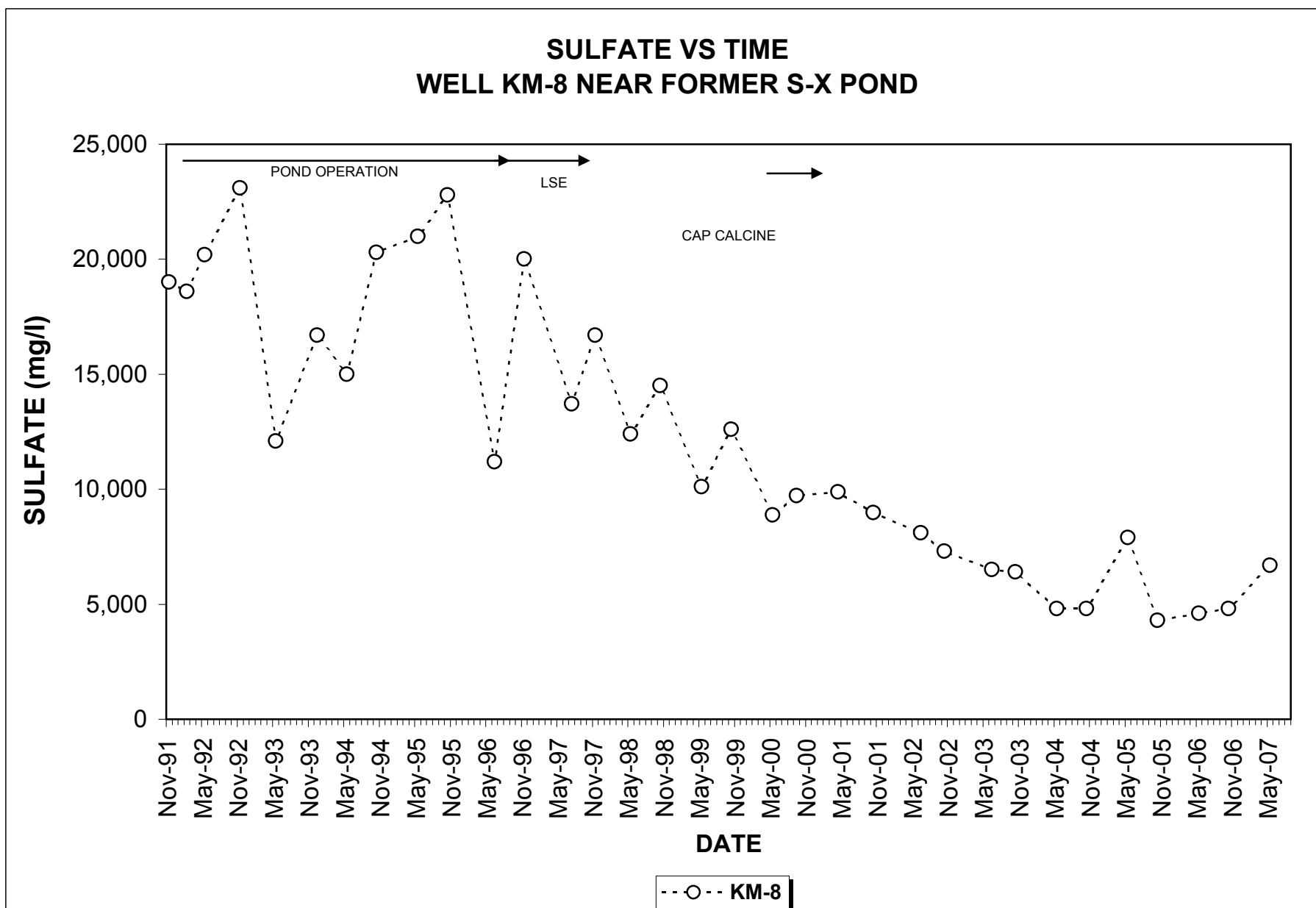


NITRATE PLUS NITRITE VS TIME UPPER AND LOWER LEDGER SPRINGS

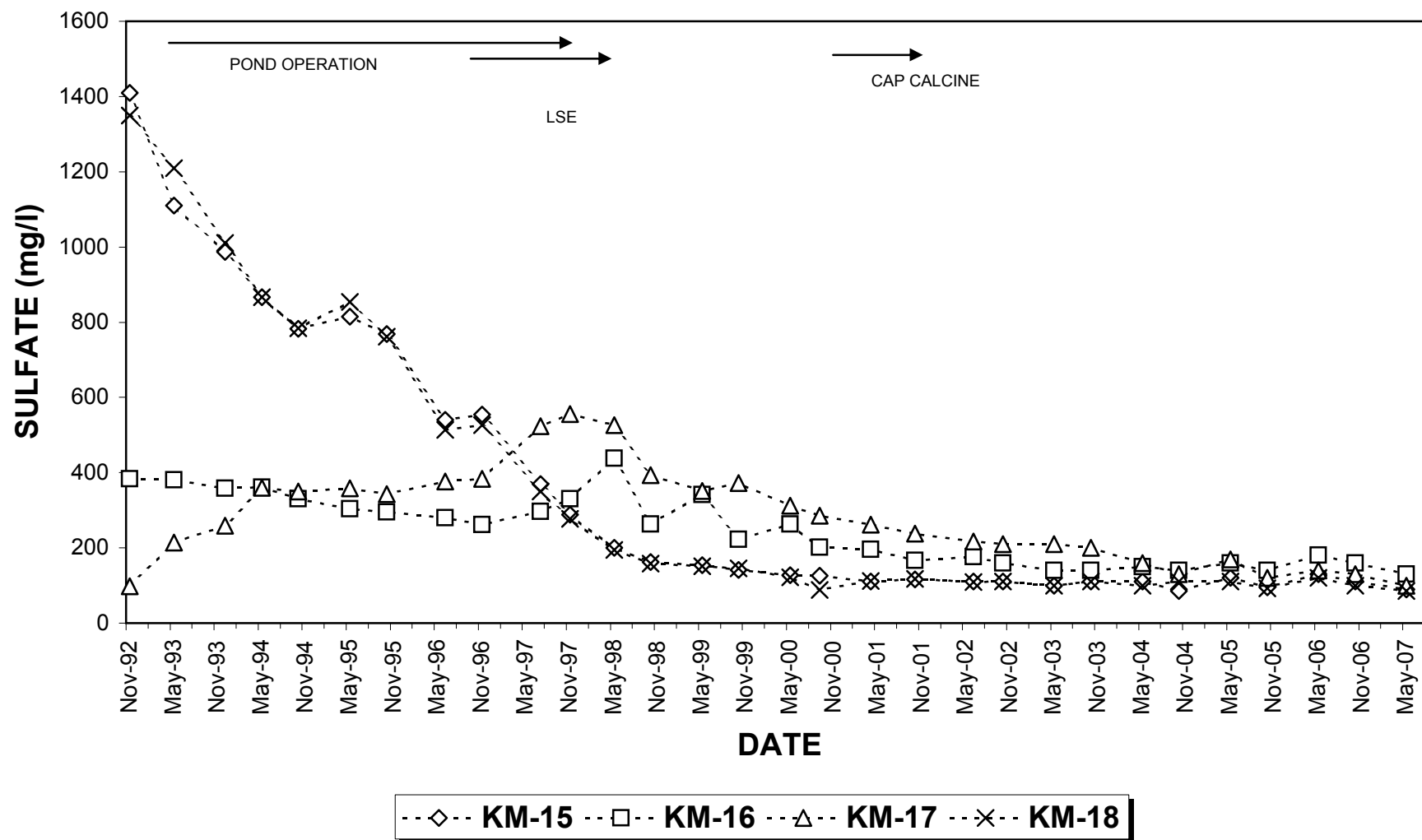


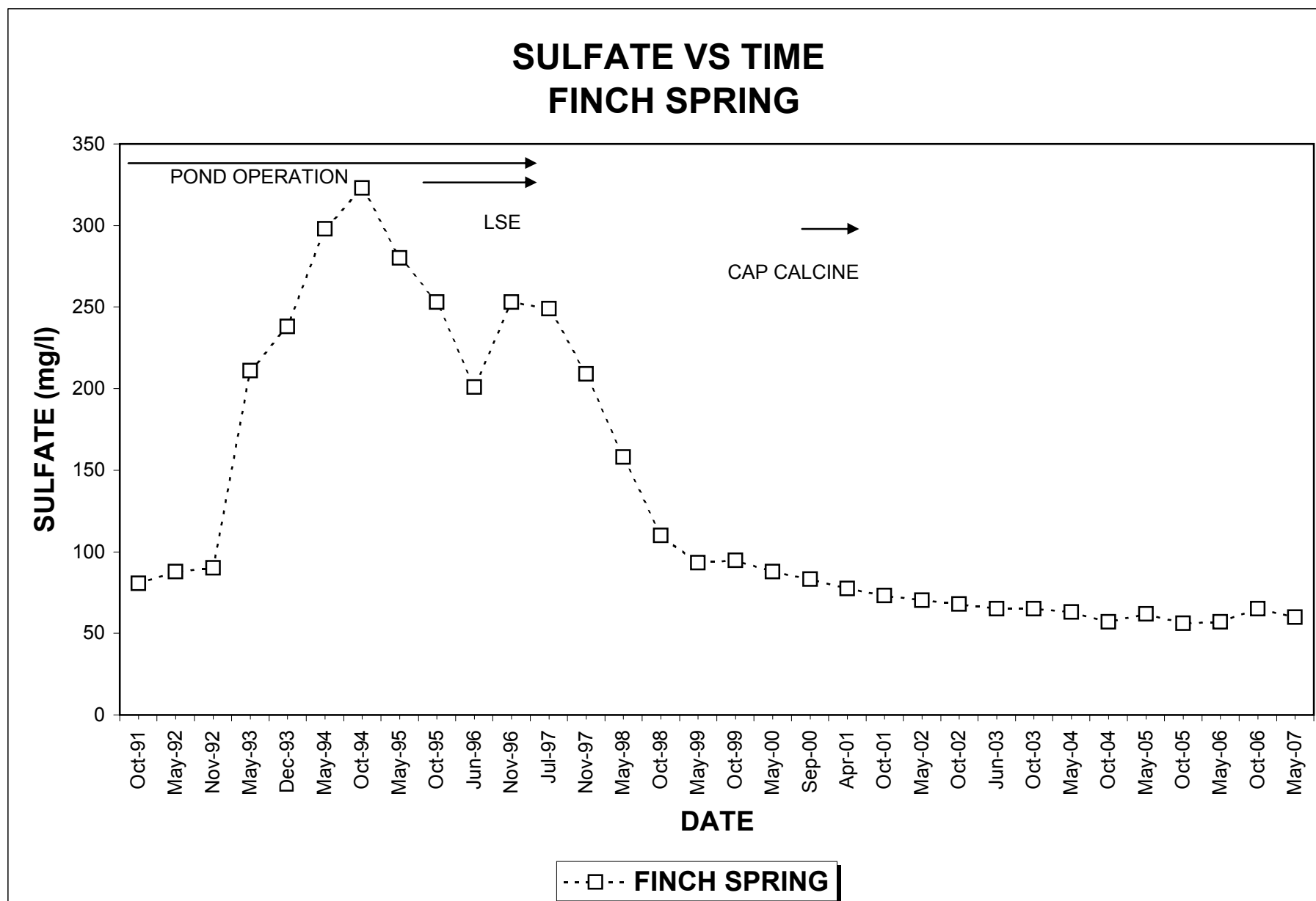




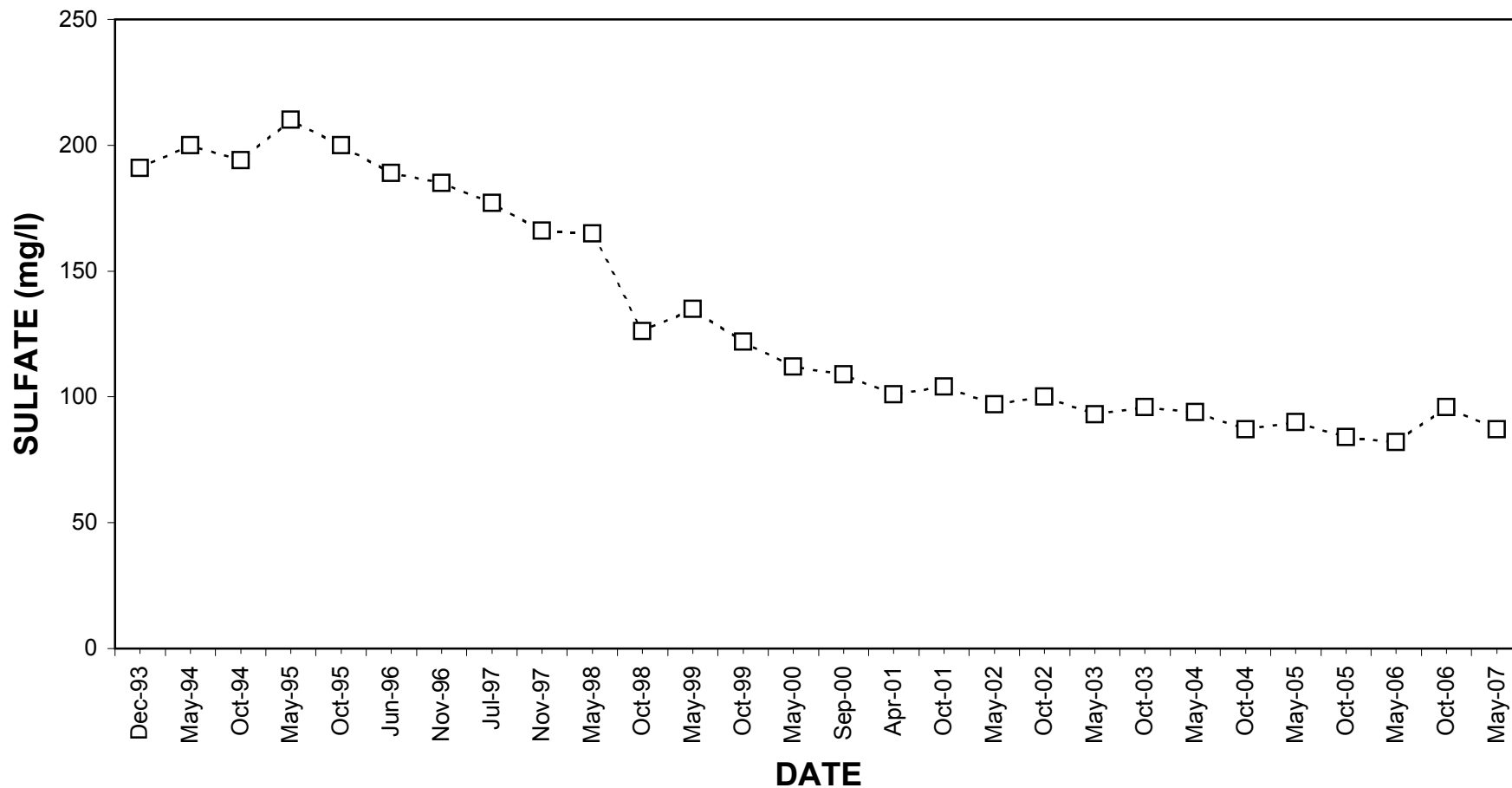


SULFATE VS TIME OFF-SITE WELLS



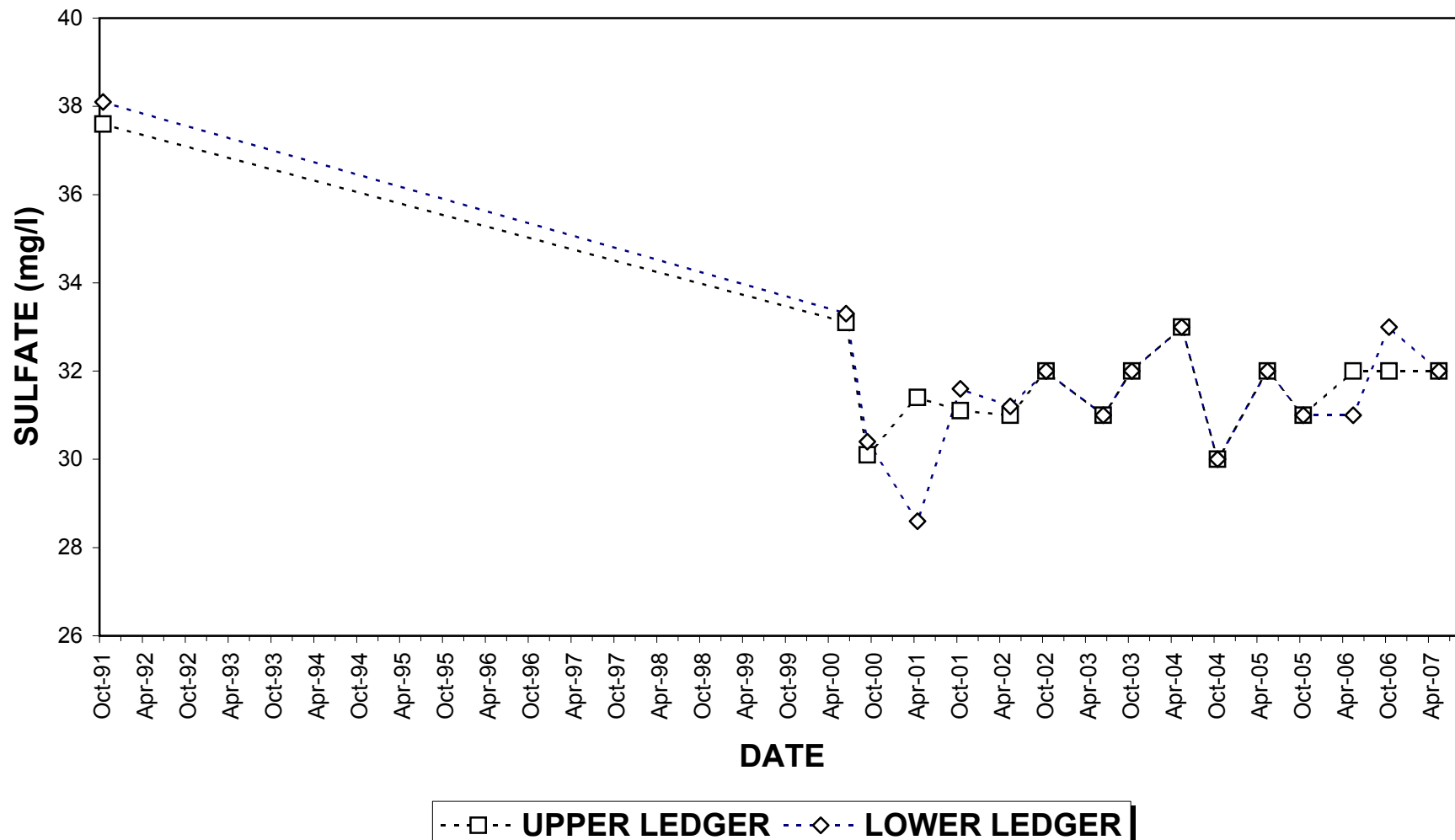


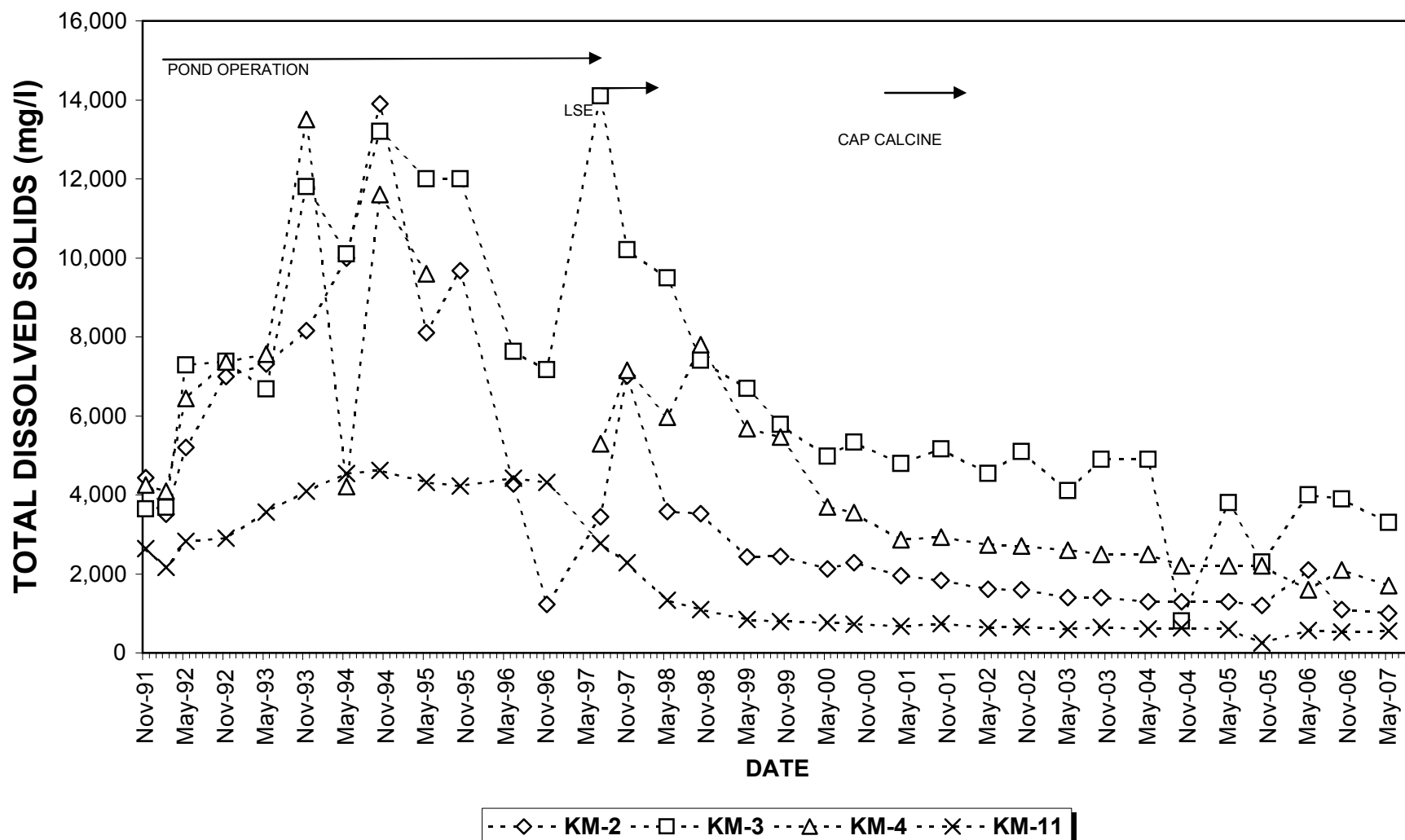
SULFATE VS TIME BIG SPRING

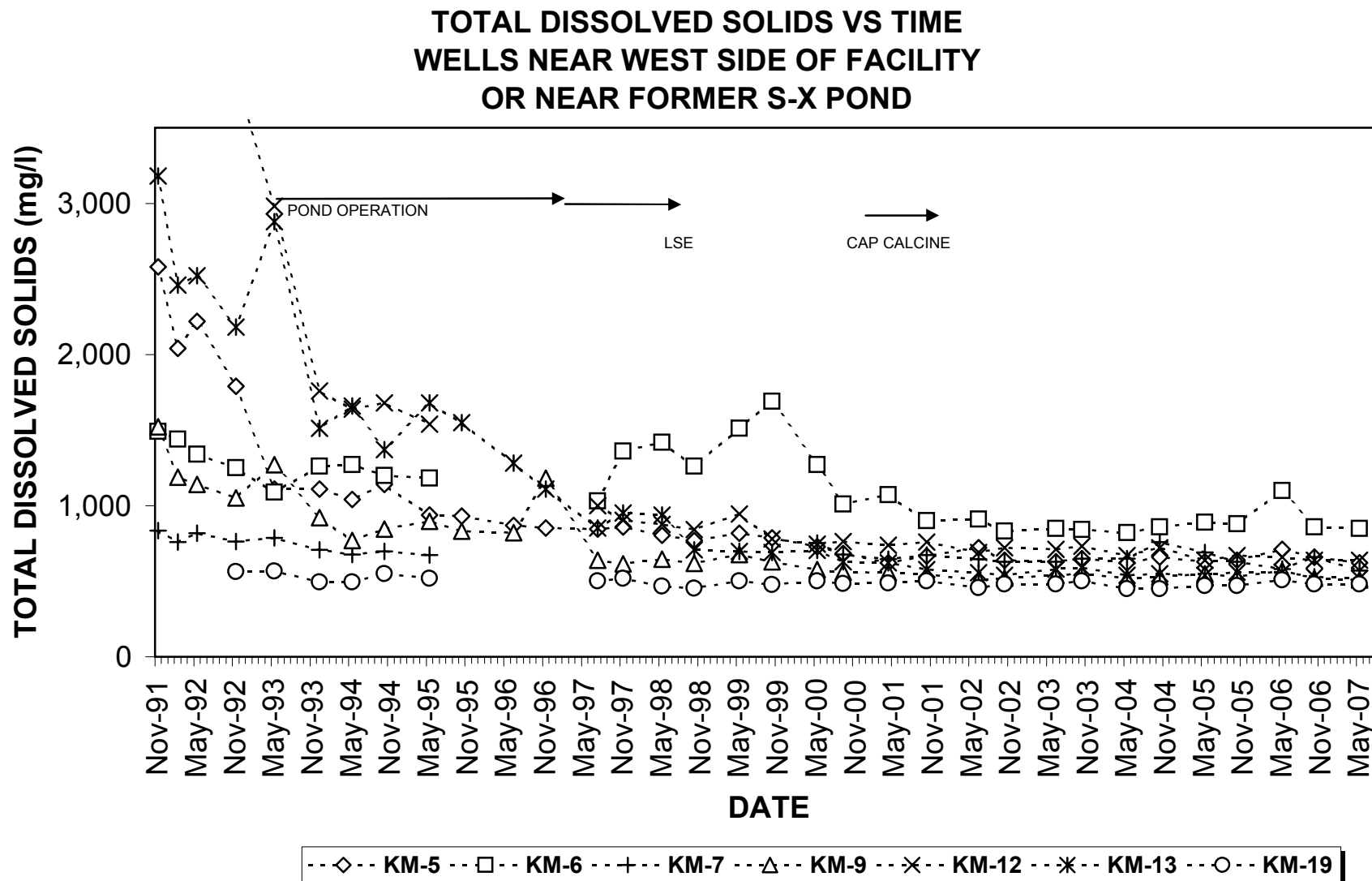


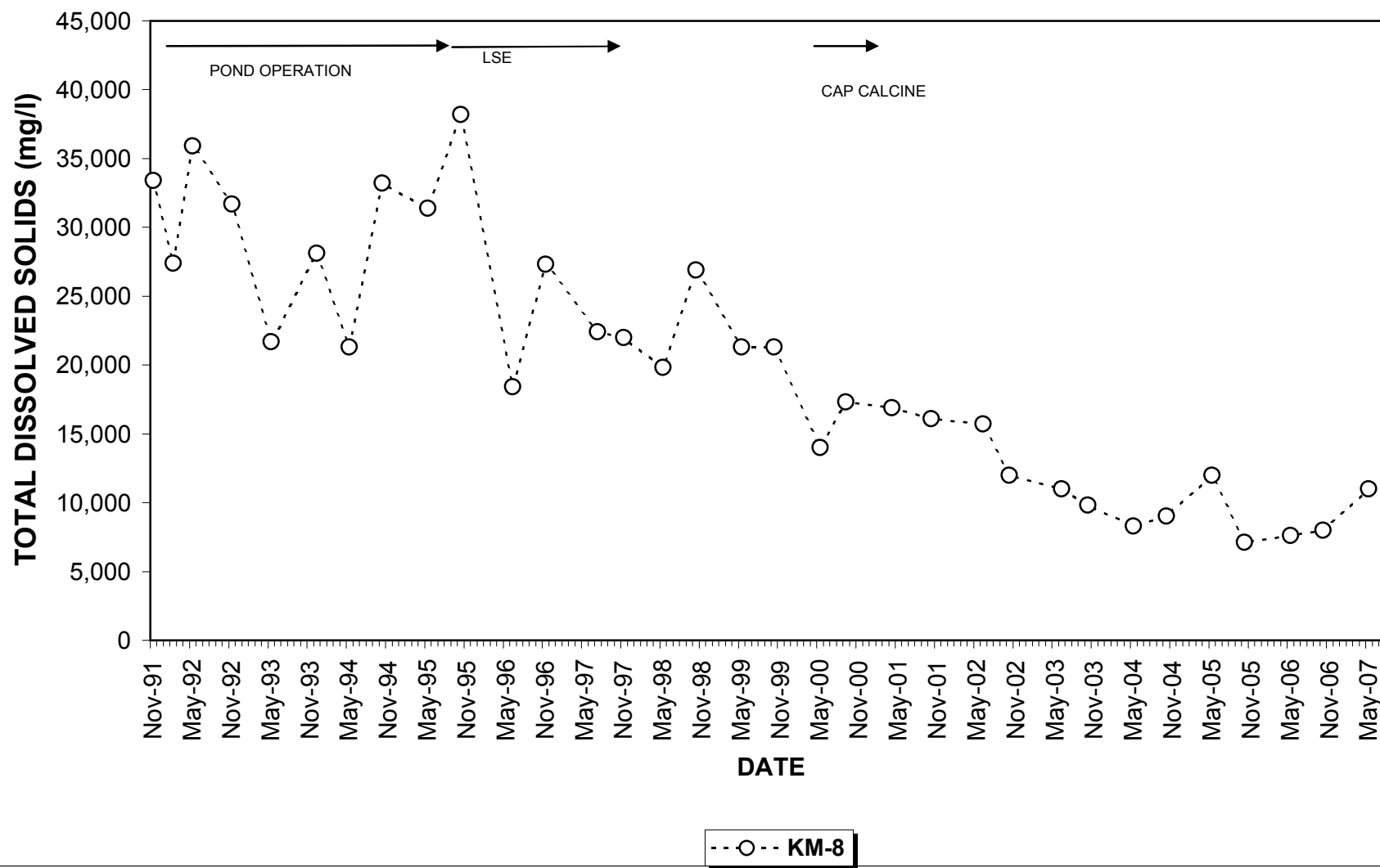
---□--- BIG SPRING

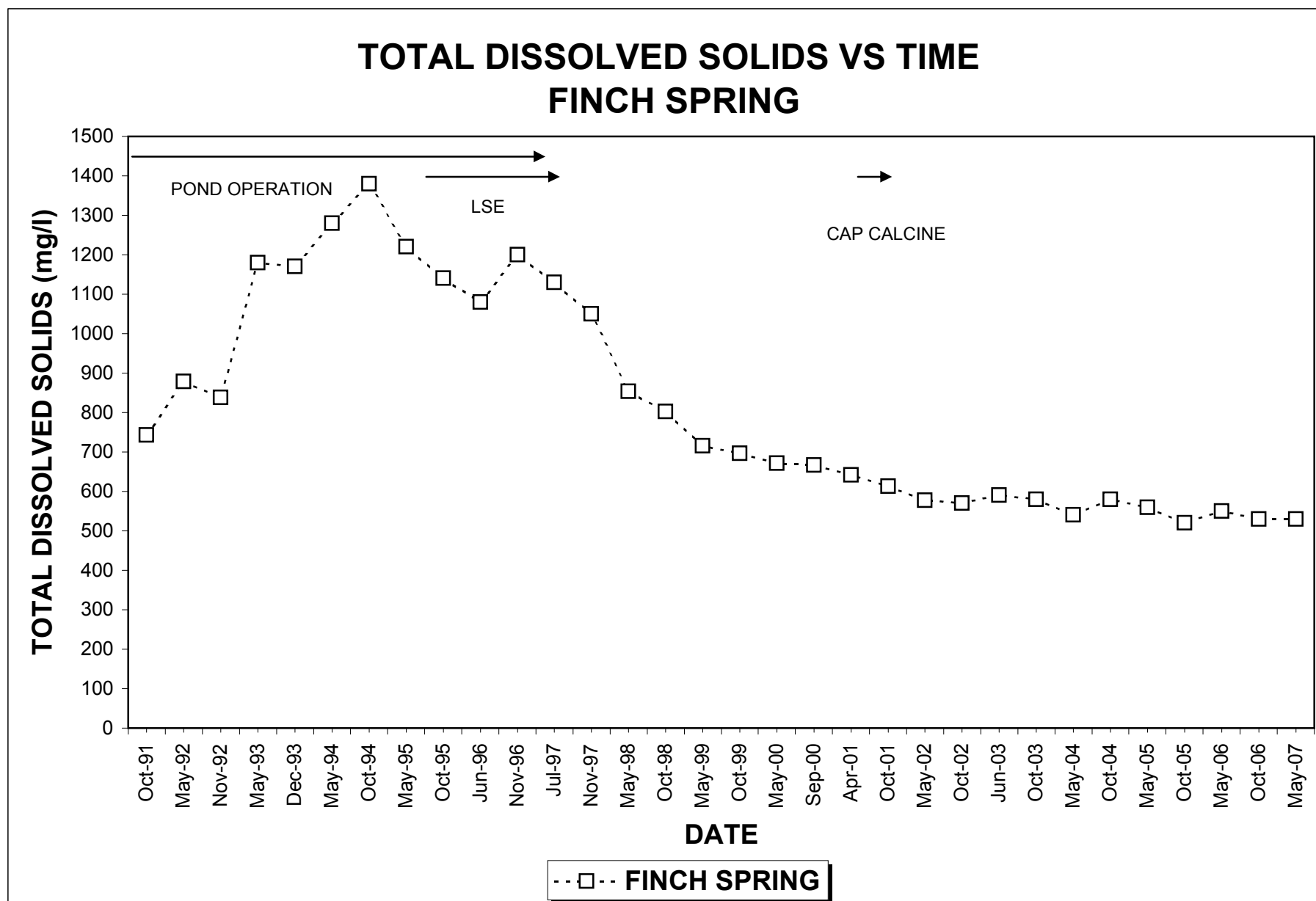
SULFATE VS TIME UPPER AND LOWER LEDGER SPRINGS

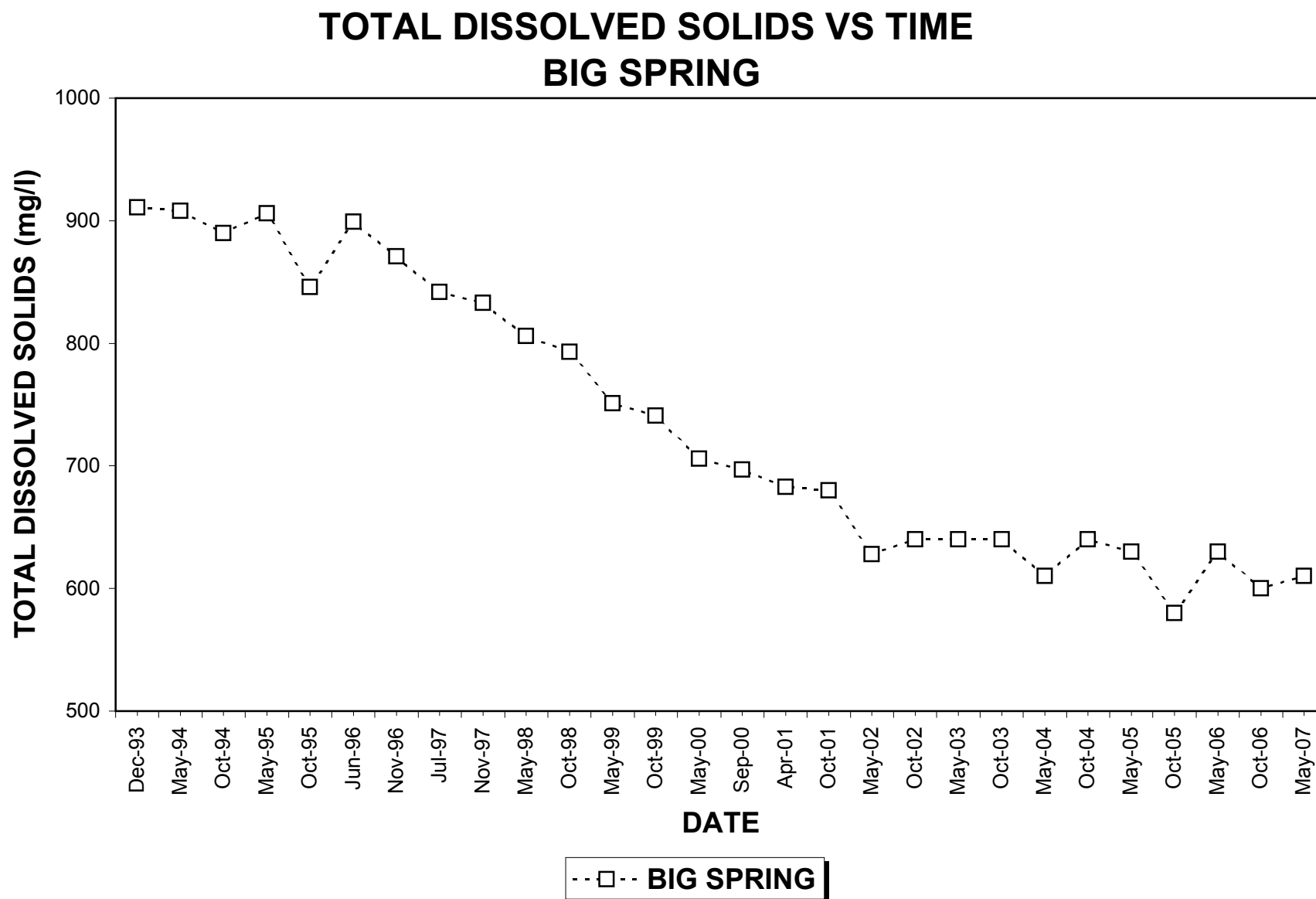


**TOTAL DISSOLVED SOLIDS VS TIME
WELLS NEAR FORMER SCRUBBER POND**

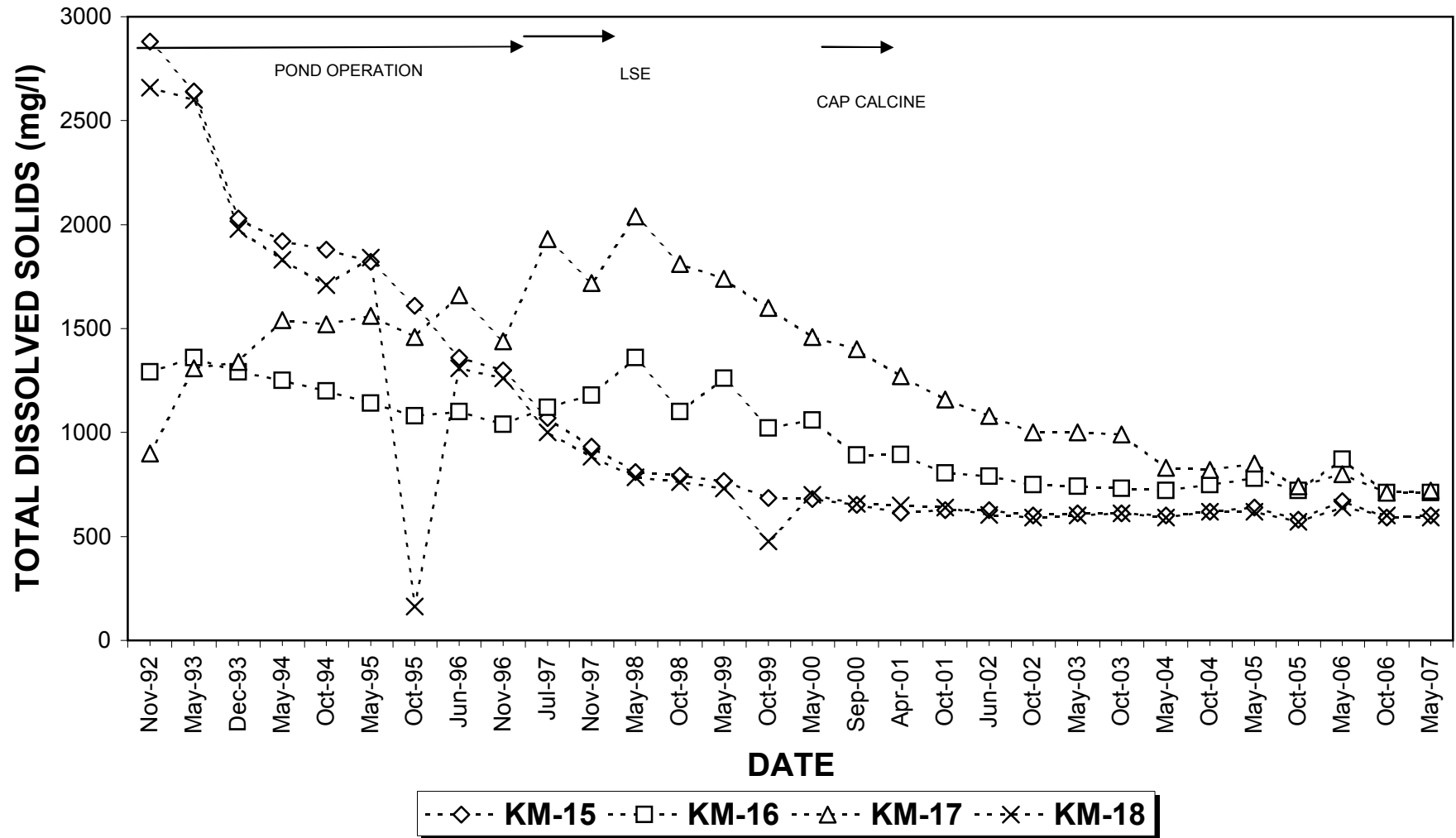


**TOTAL DISSOLVED SOLIDS VS TIME
WELL KM-8 NEAR FORMER S-X POND**

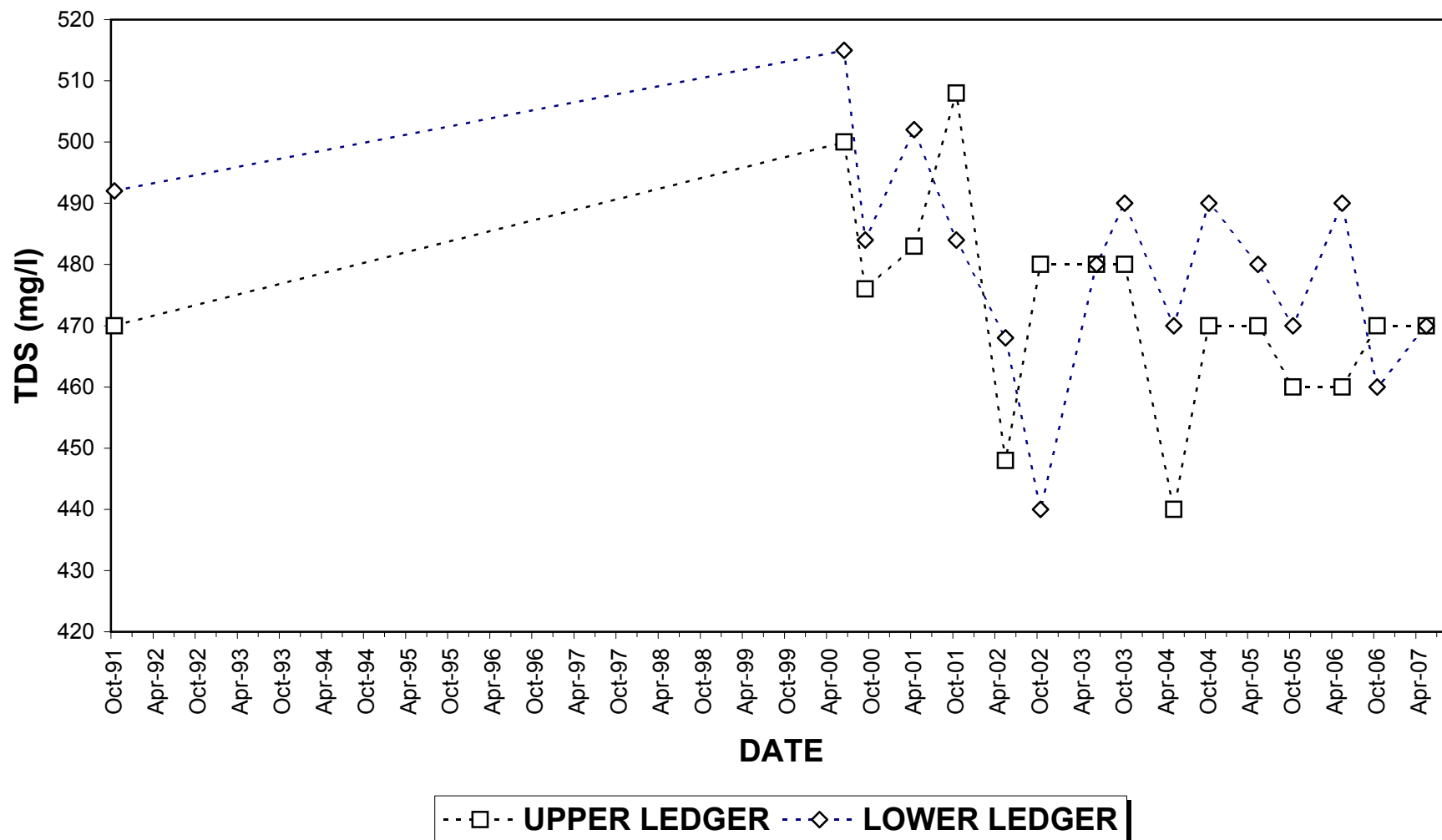


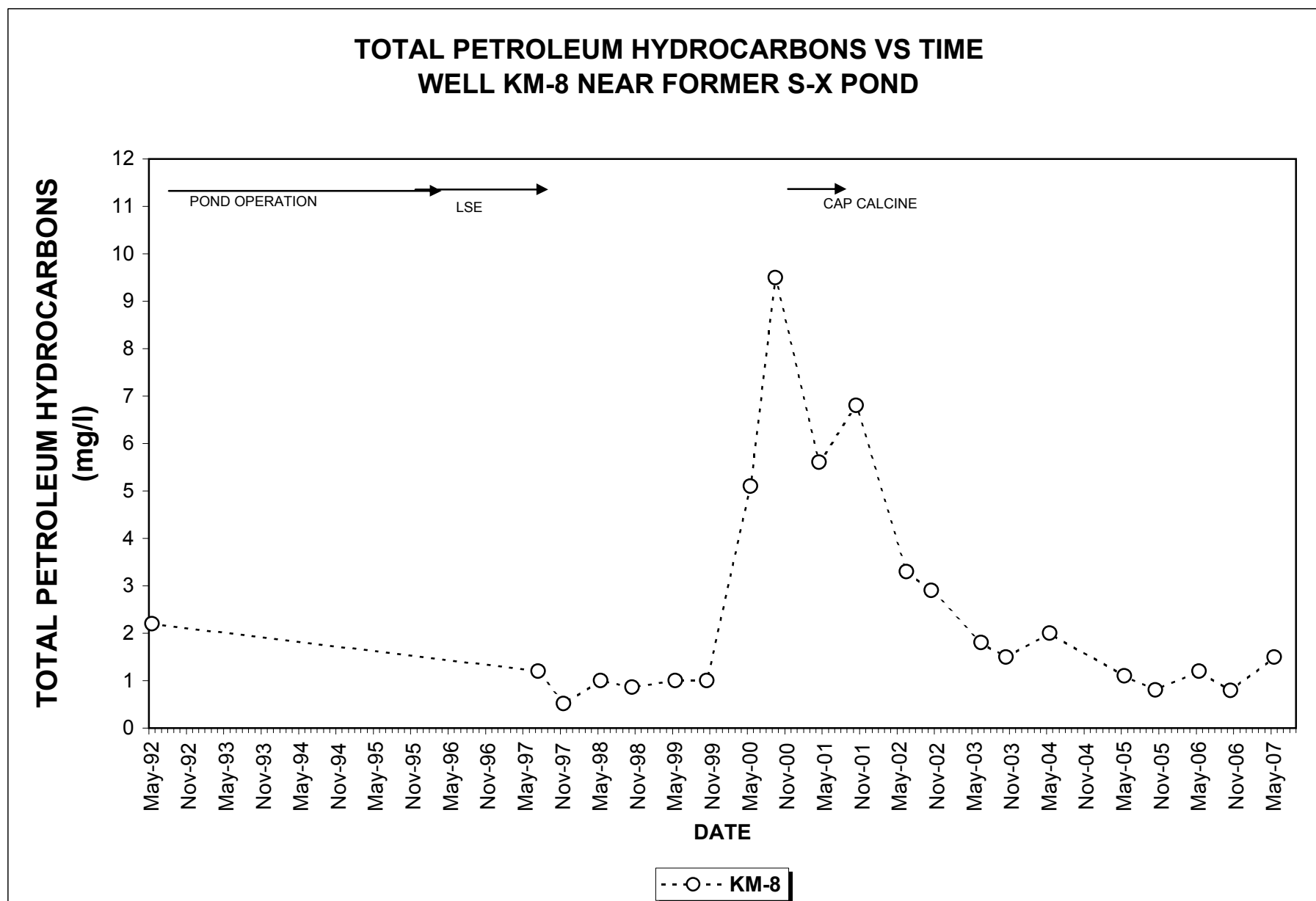


TOTAL DISSOLVED SOLIDS VS TIME OFF-SITE WELLS



TDS VS TIME UPPER AND LOWER LEDGER SPRINGS

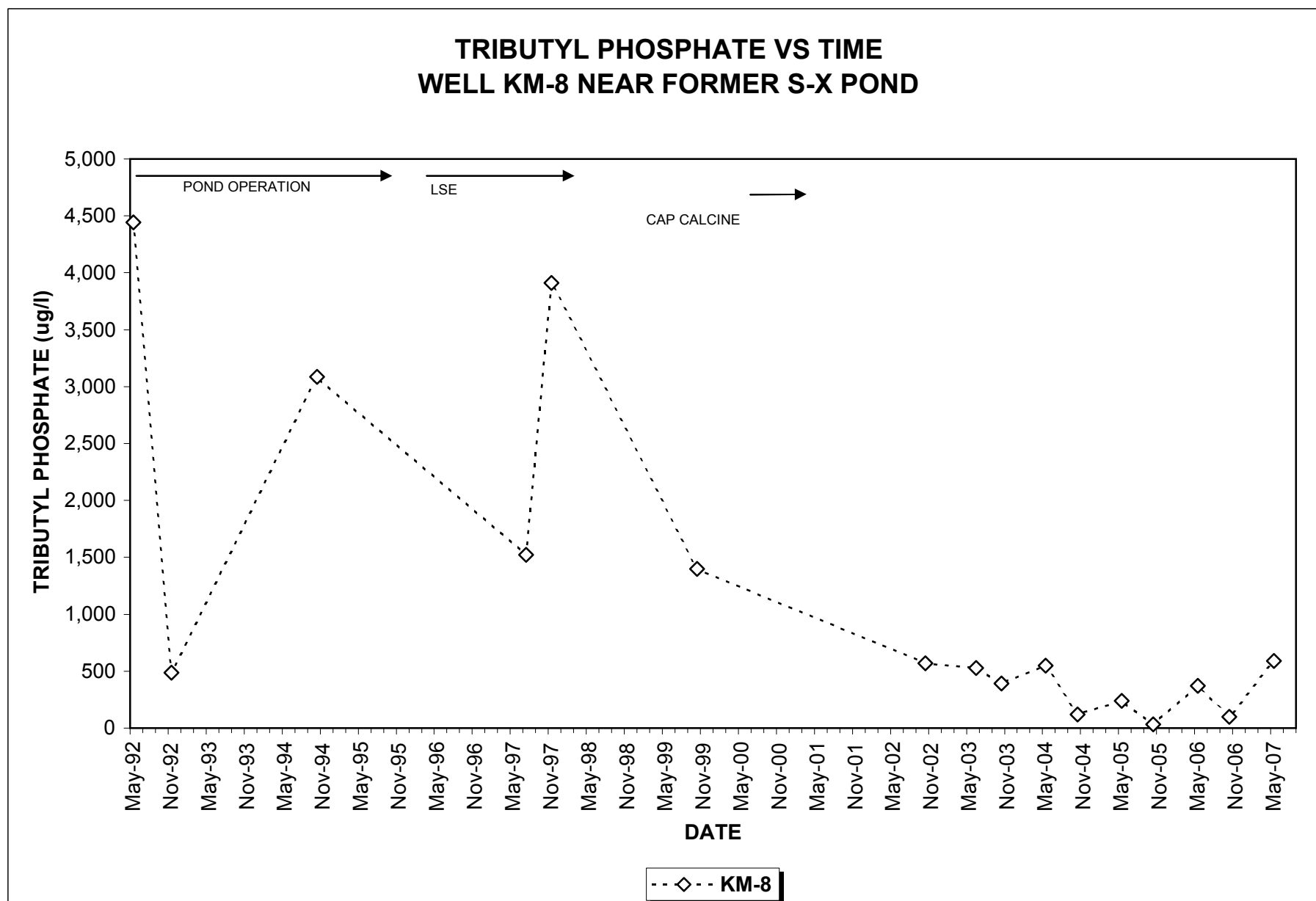




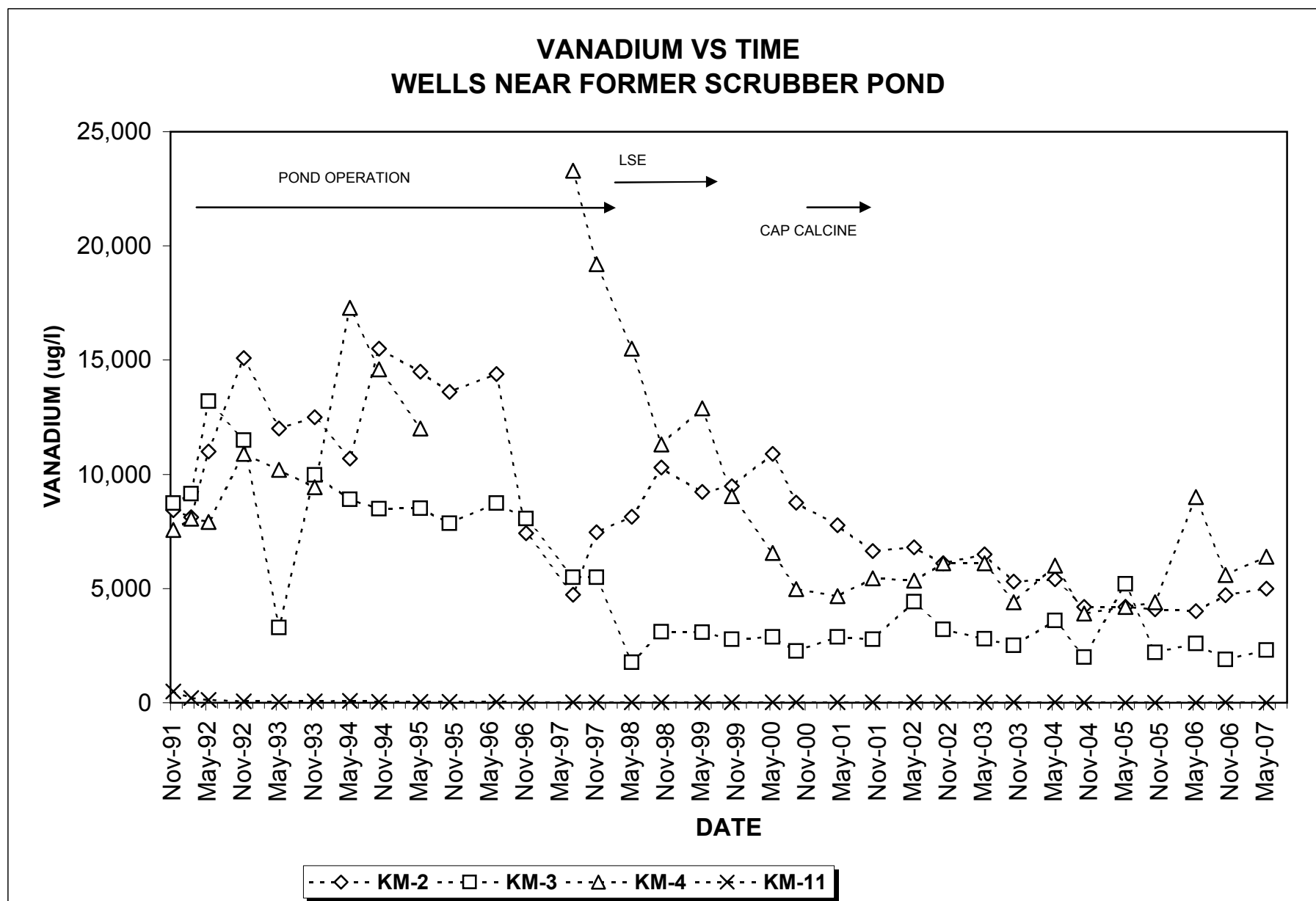
RBC FOR TPH IS 0.73 mg/l

KM-8 IS A POC WELL

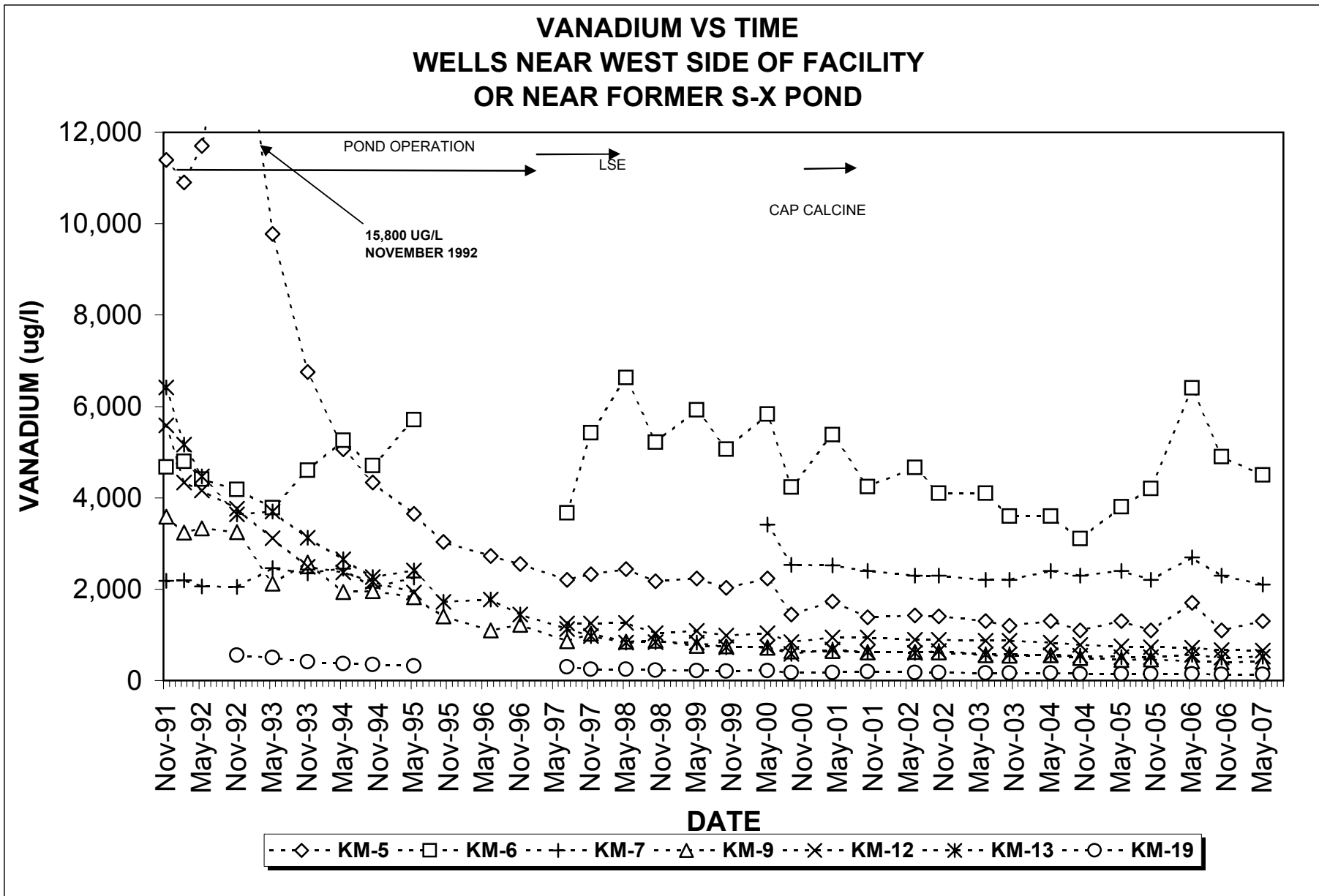
1999 VALUES LESS THAN DETECTION



RBC FOR TRIBUTYL PHOSPHATE IS 180 $\mu\text{g/l}$
KM-8 IS A POC WELL
VALUES ESTIMATED AS DETECTED

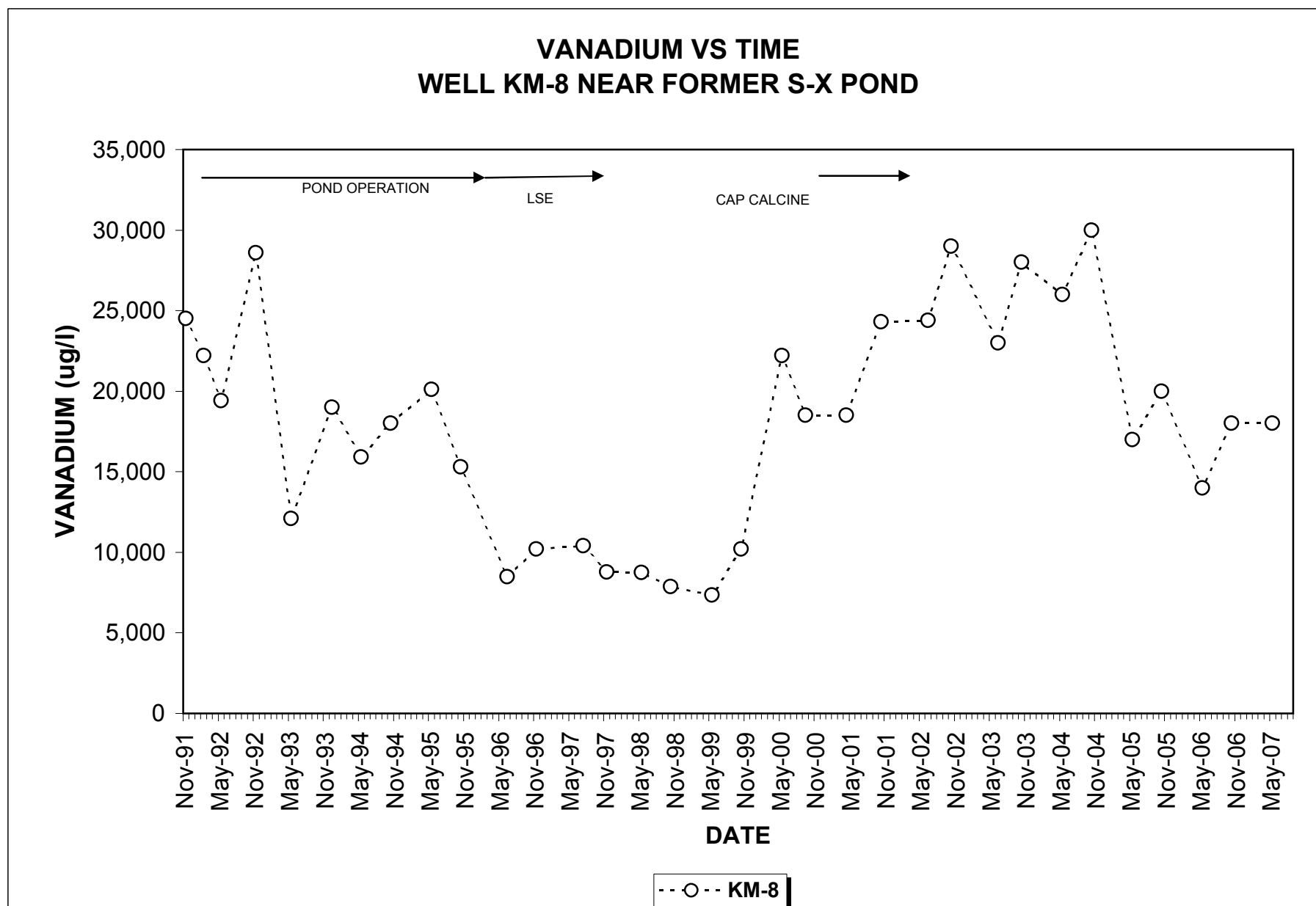


RBC FOR VANADIUM IS 260 ug/l
KM-2, KM-3, KM-11 ARE POC WELLS

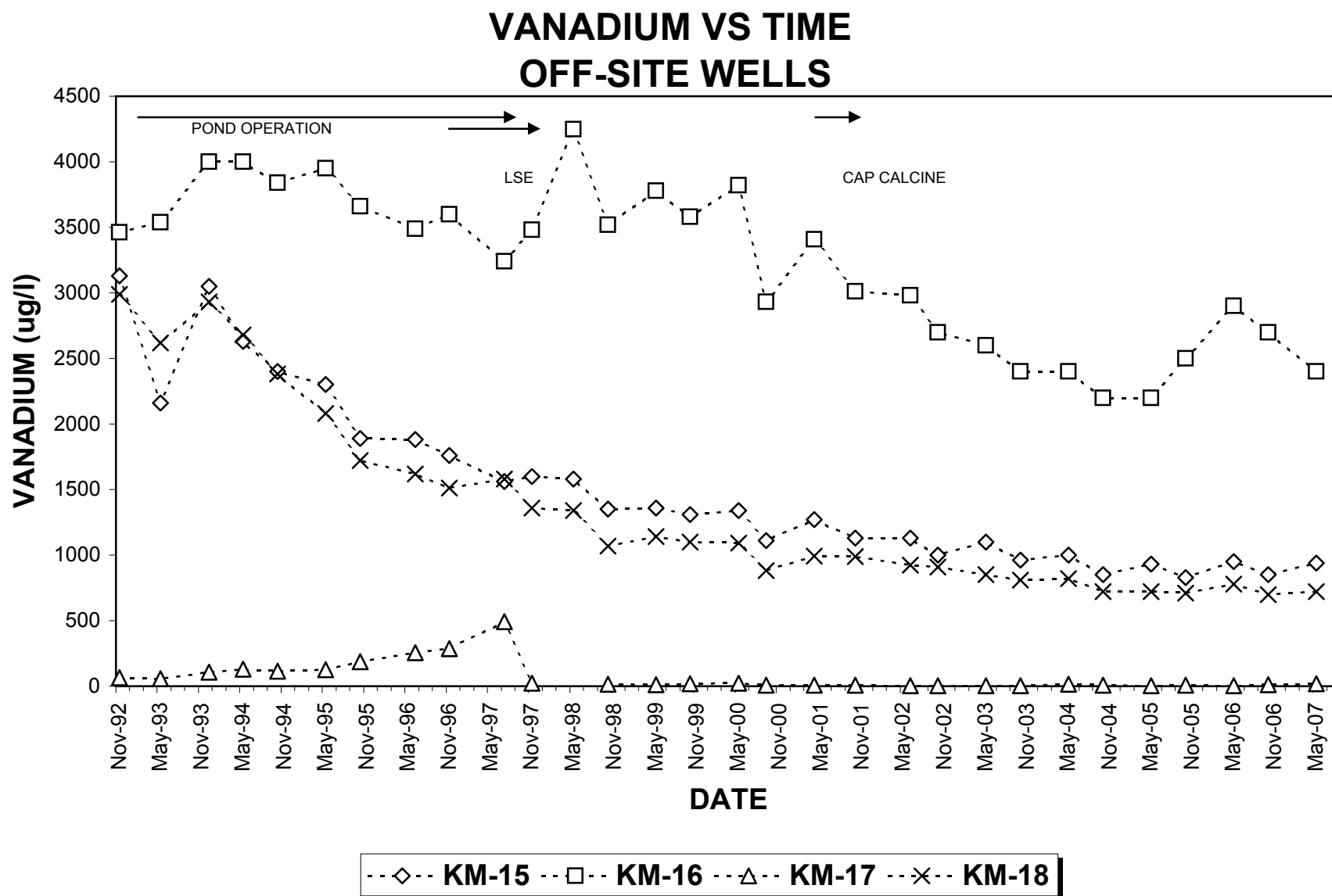


RBC FOR VANADIUM IS 260 ug/l

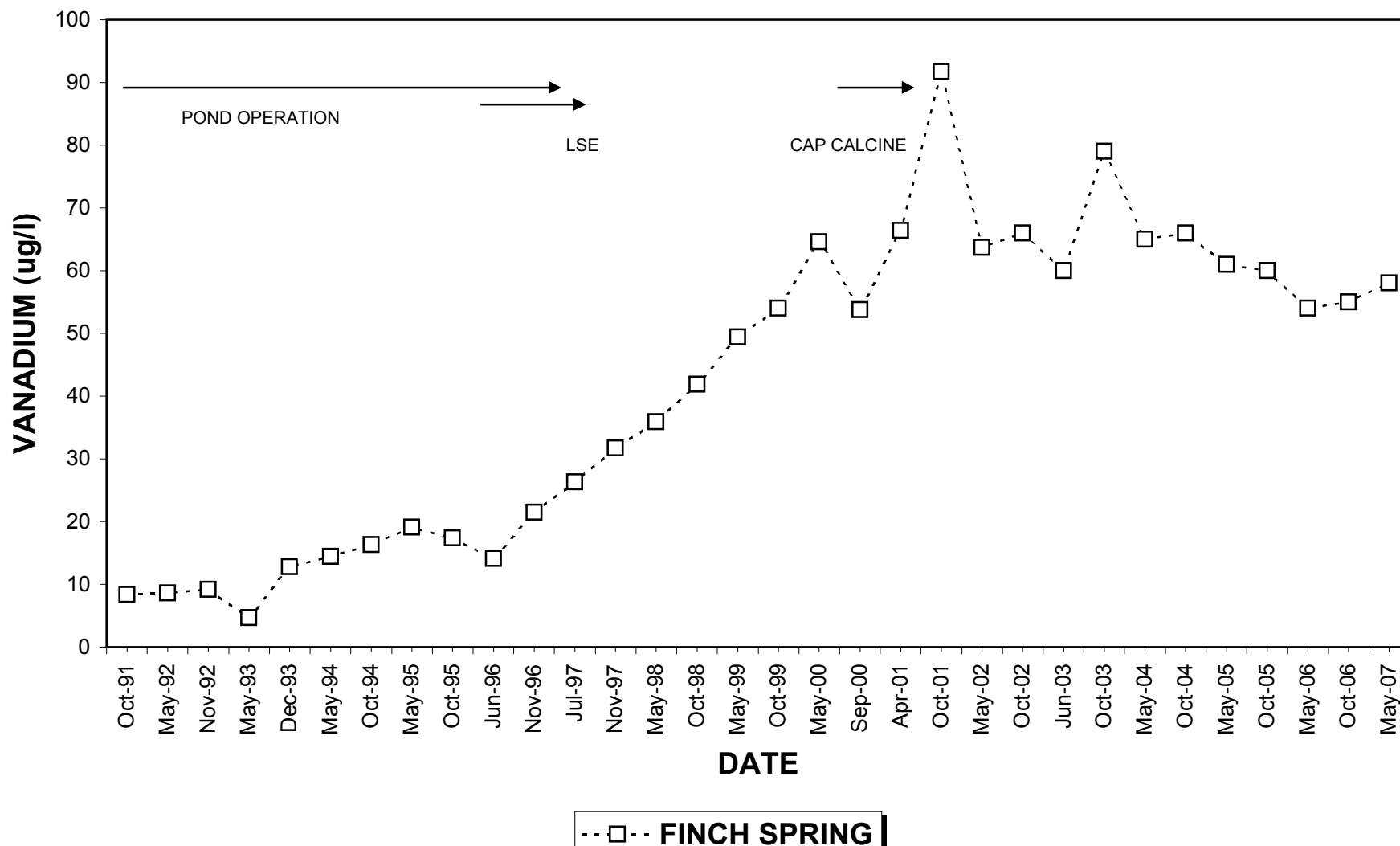
KM-5, KM-9, KM-12, KM-13, KM-19 ARE POC WELLS

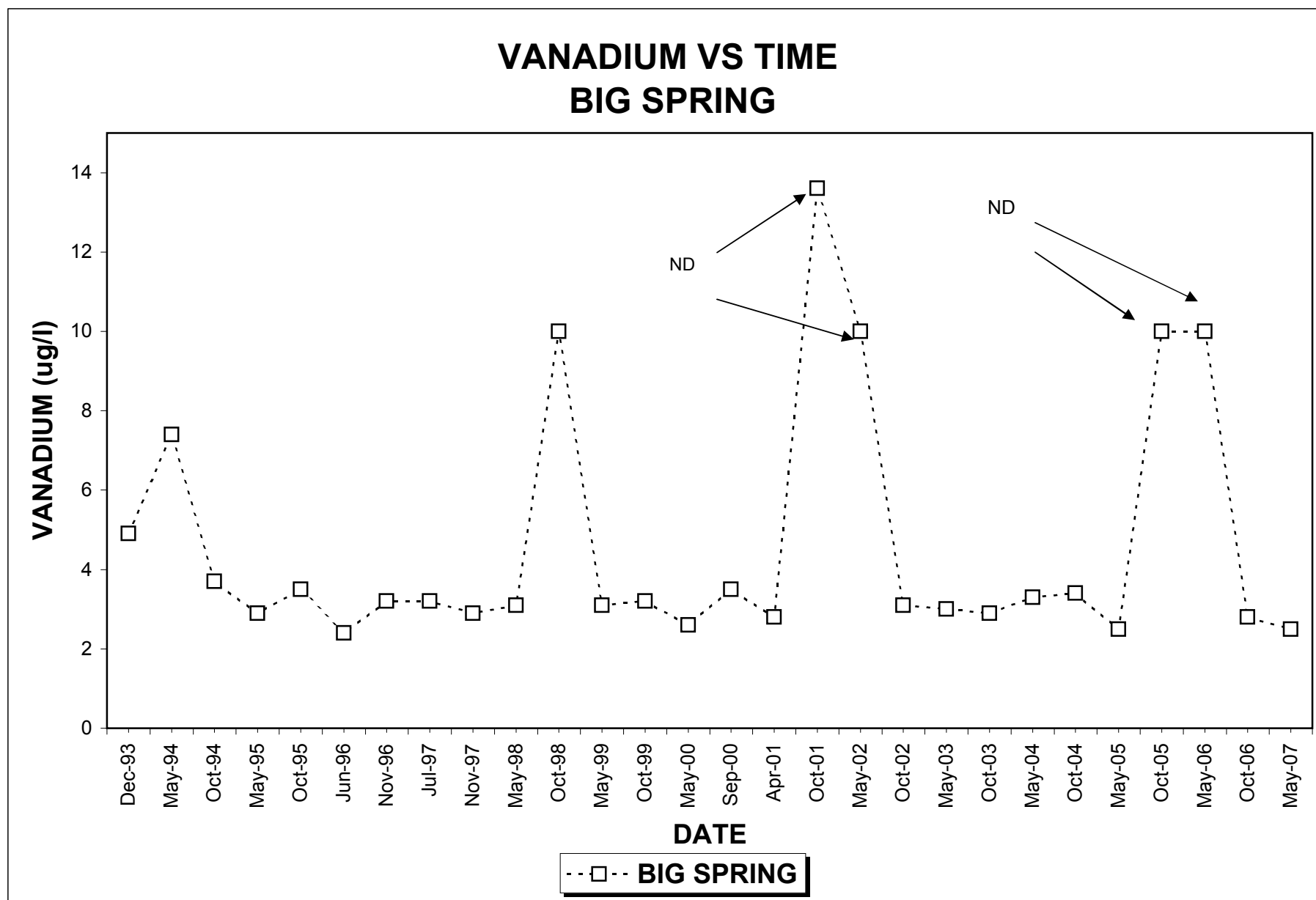


RBC FOR VANADIUM IS 260 ug/l
KM-8 IS A POC WELLS



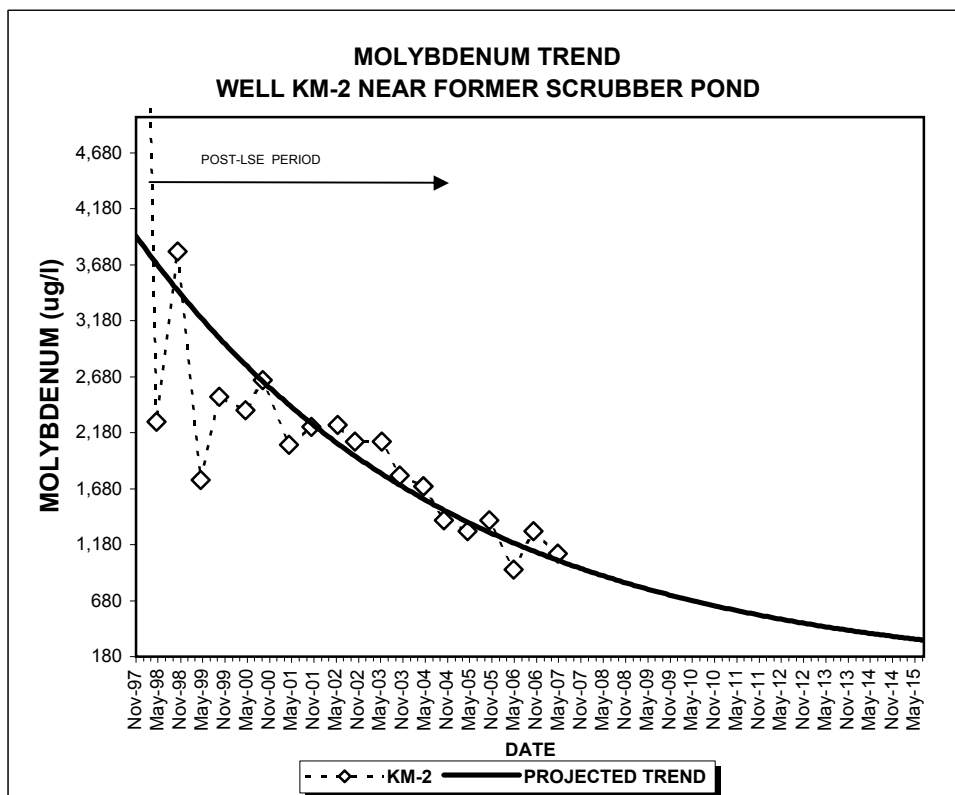
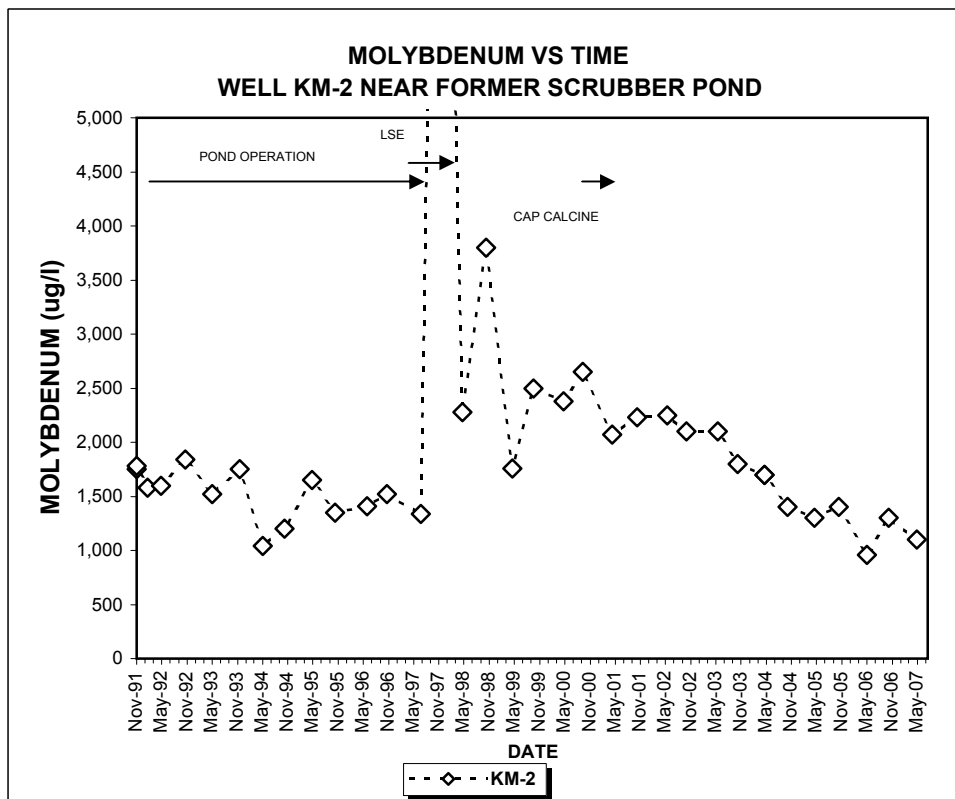
VANADIUM VS TIME FINCH SPRING



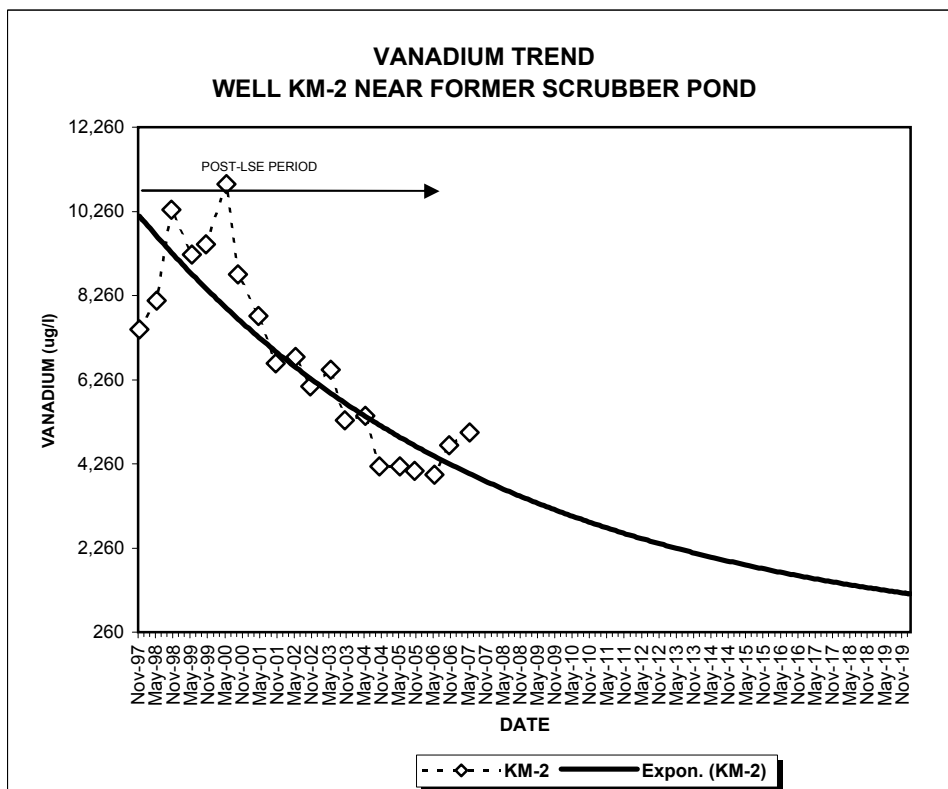
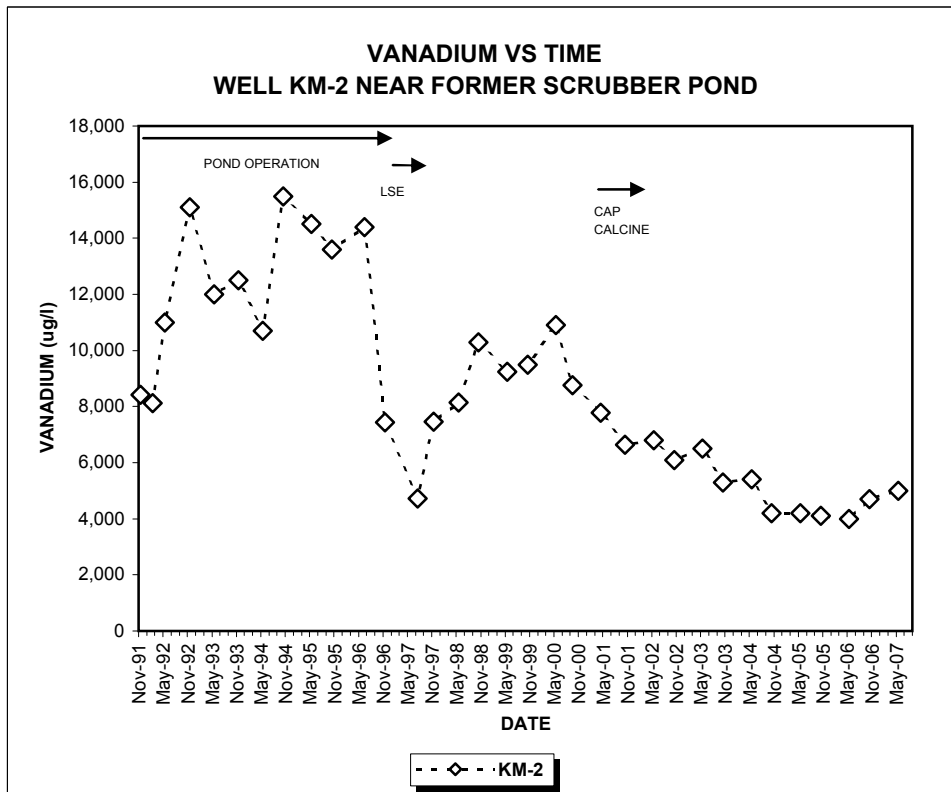


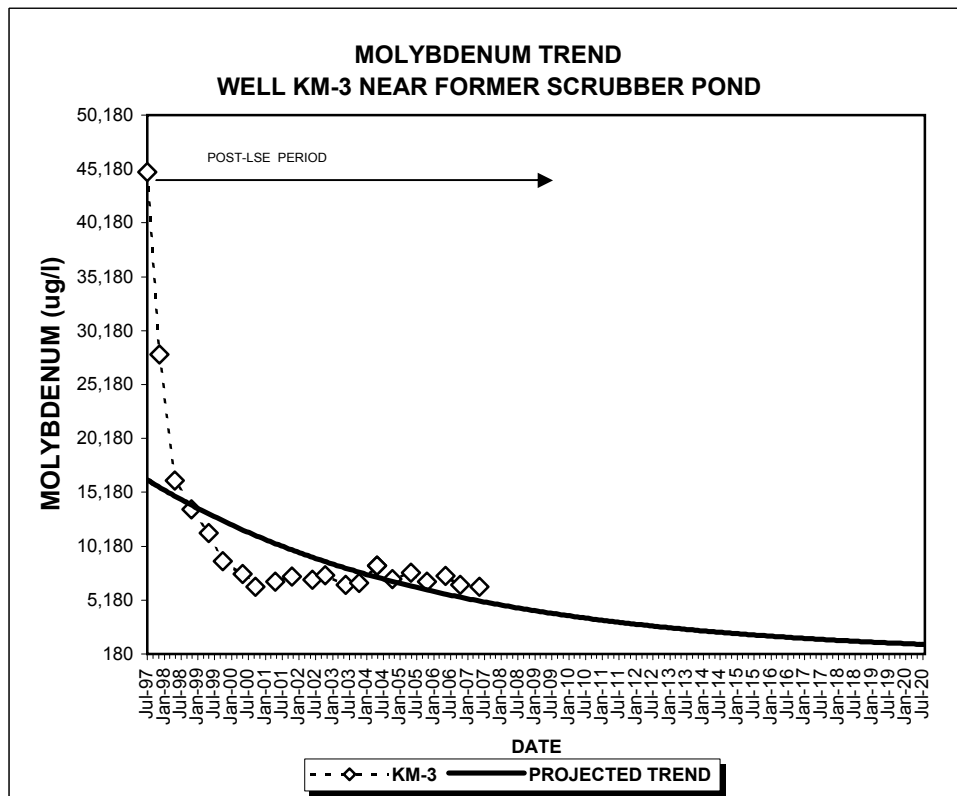
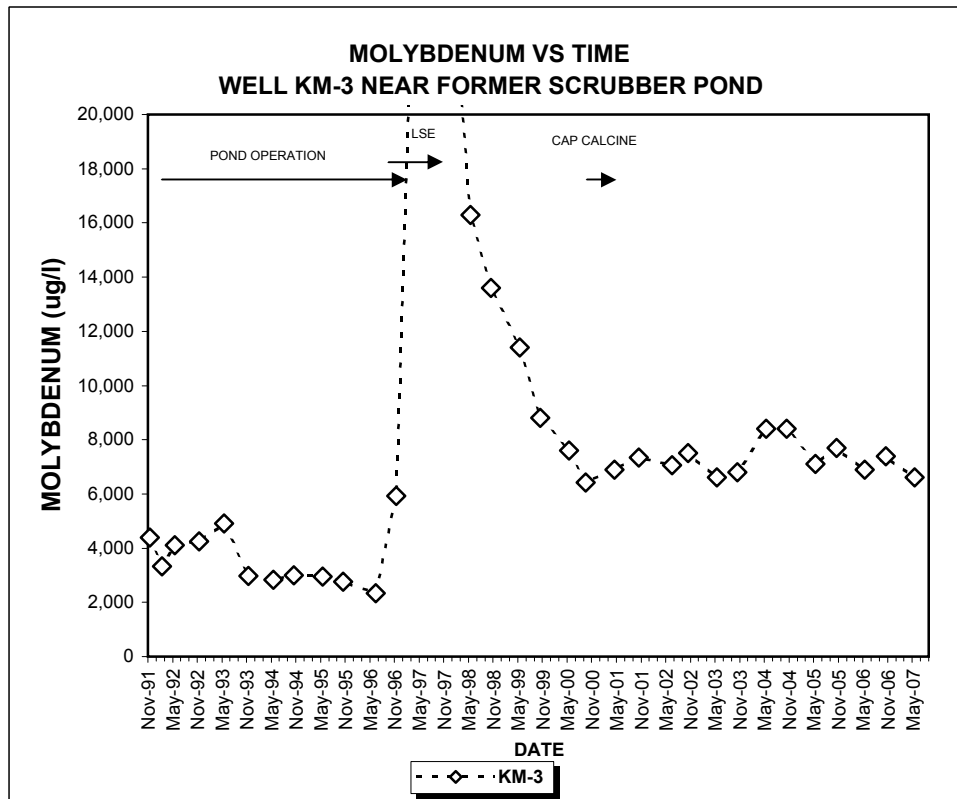
Values less than detection annotated on figure

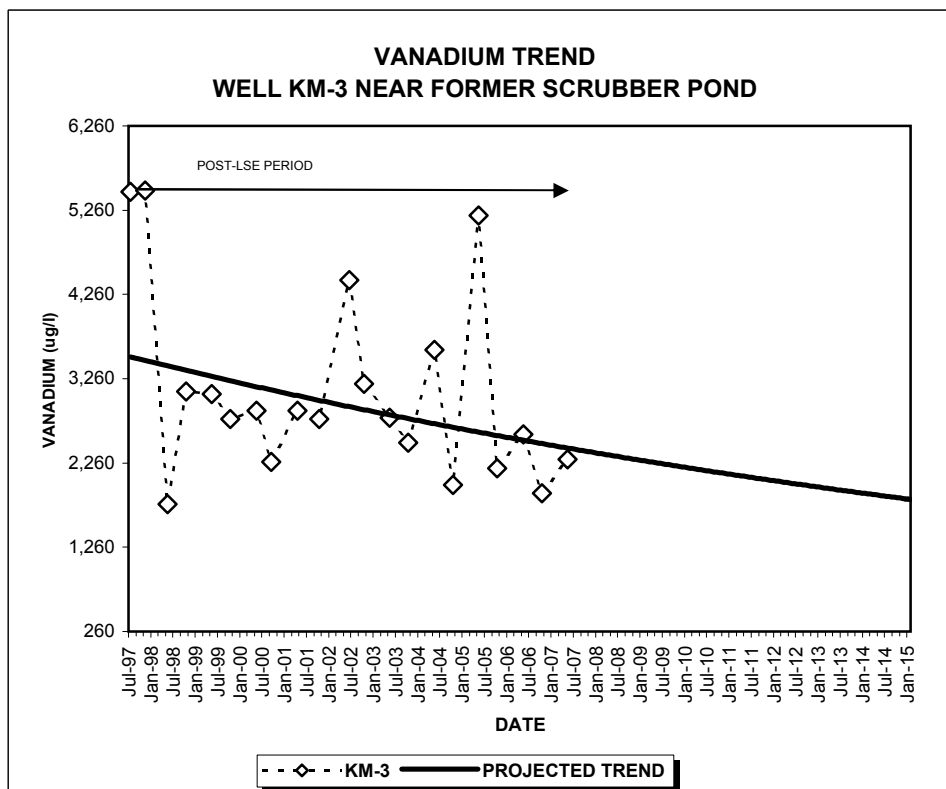
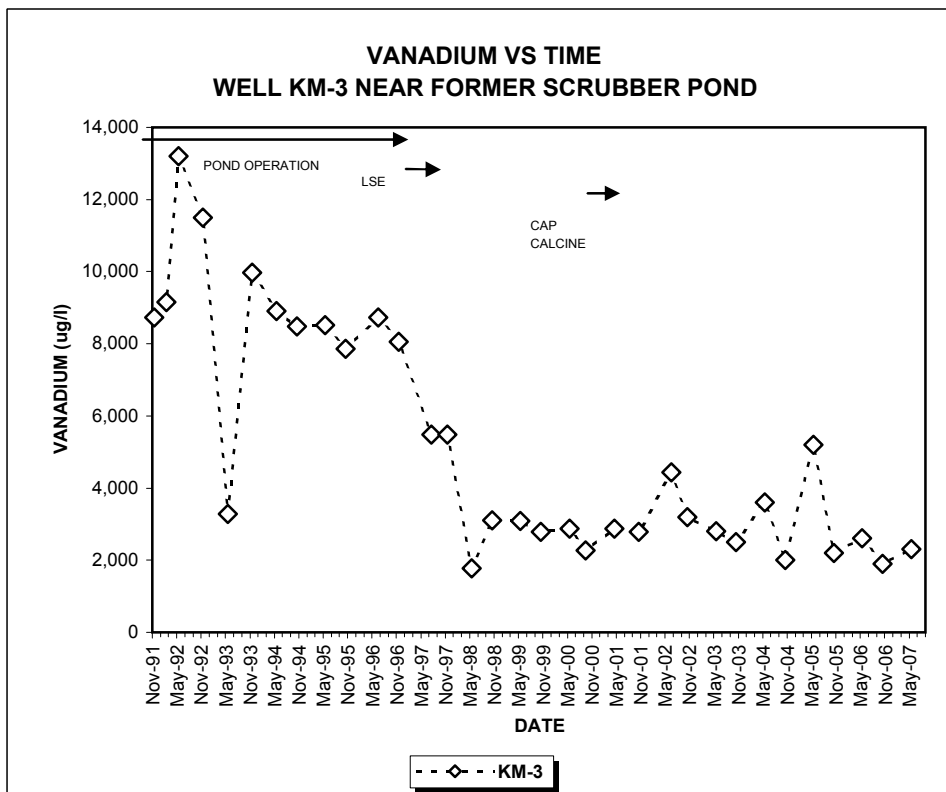
APPENDIX B
COC CONCENTRATION TRENDS WITH TIME
APPENDIX AND PROJECTED TRENDS



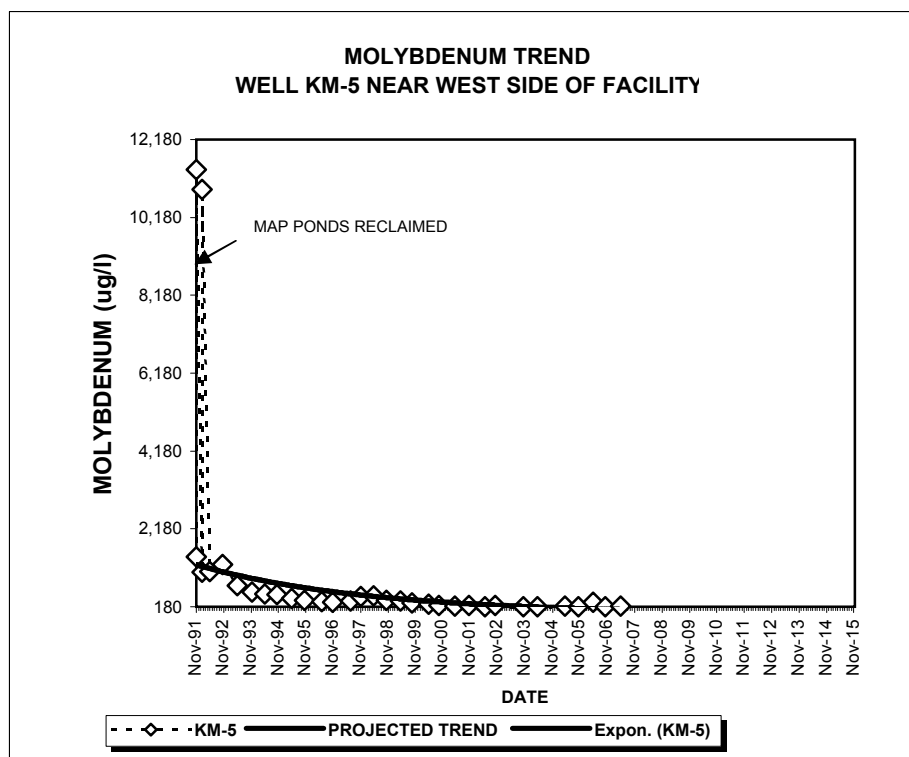
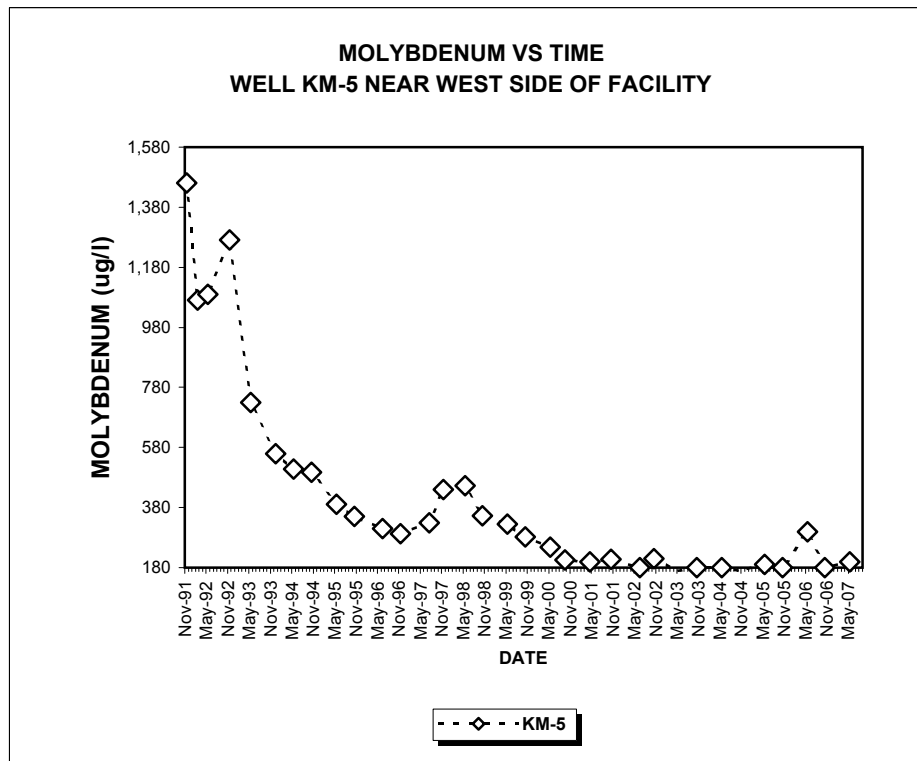
FIGURE







COC CONCENTRATION TRENDS WITH TIME AND PROJECTED TRENDS

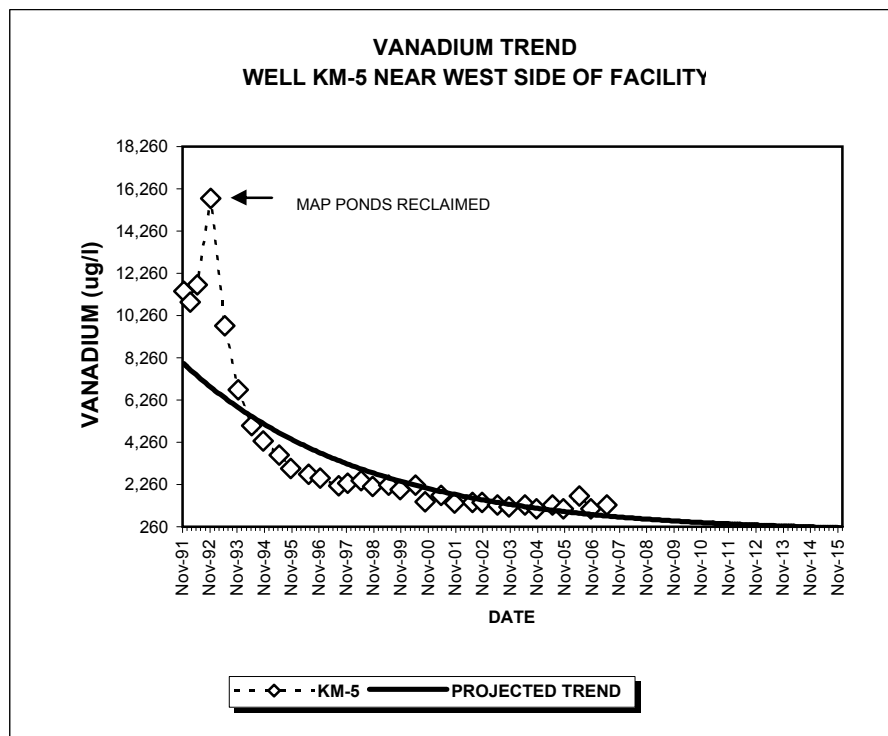
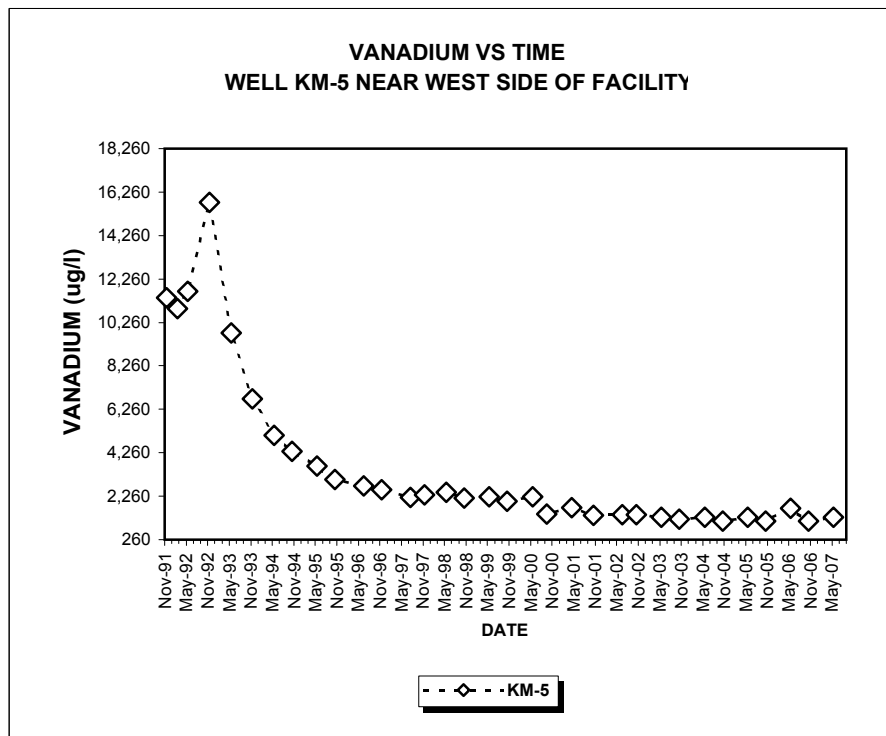


RBC FORMOLYBDENUM IS 180 UG/L

KM-5 IS A POC WELL

PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING LSE

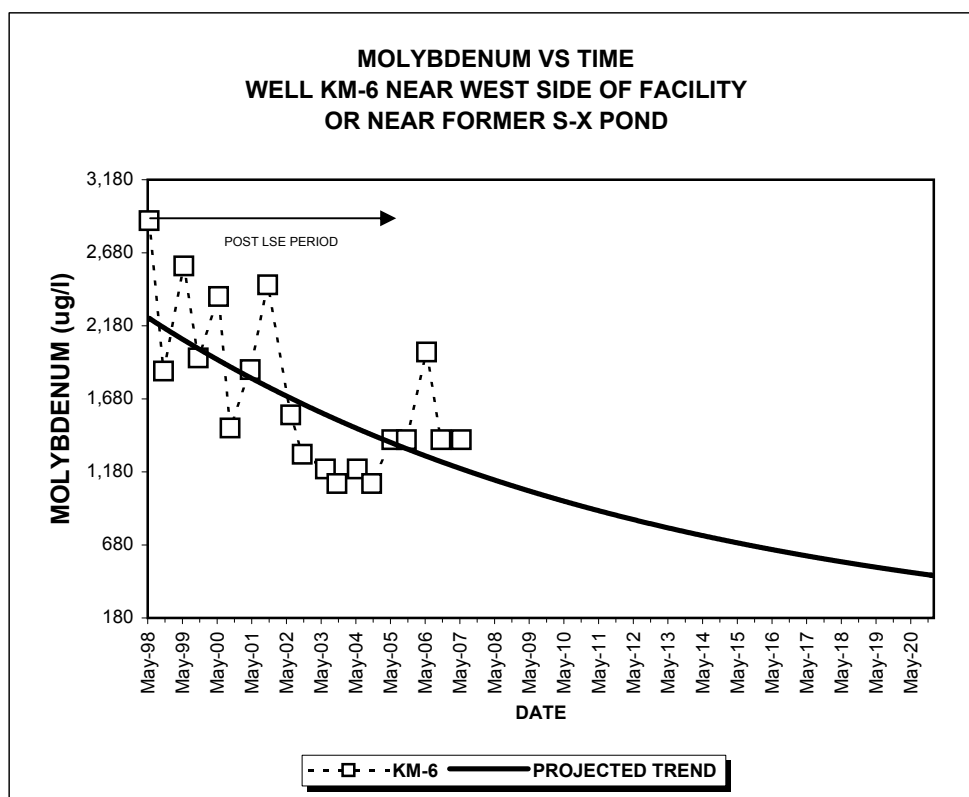
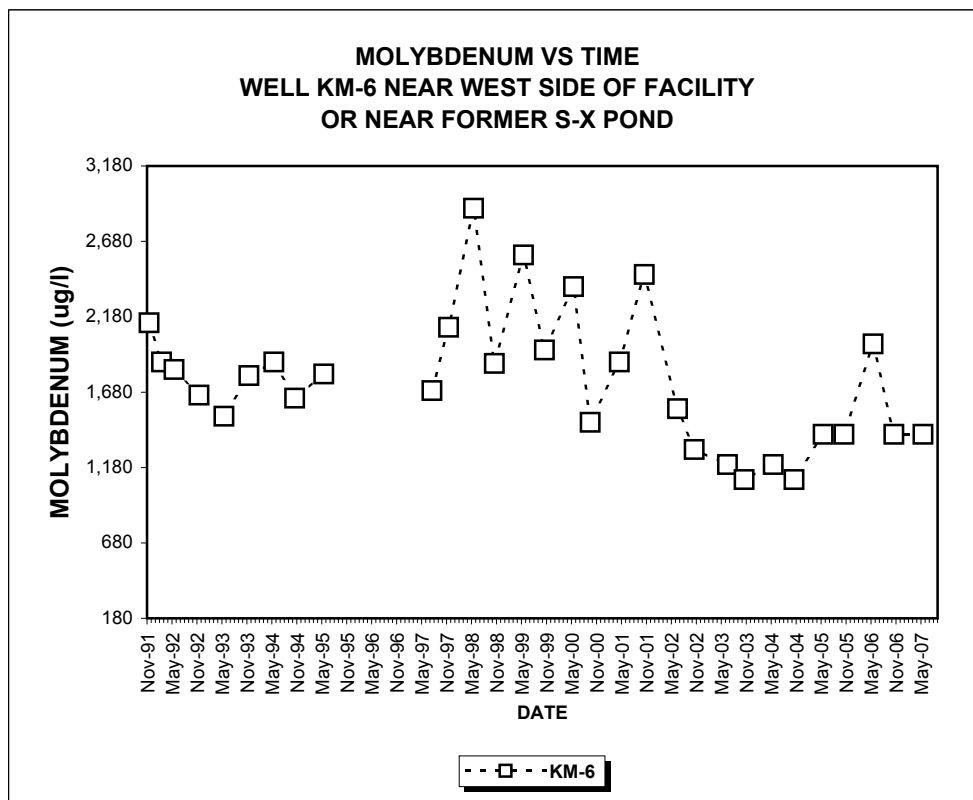
COC CONCENTRATION TRENDS WITH TIME AND PROJECTED TRENDS



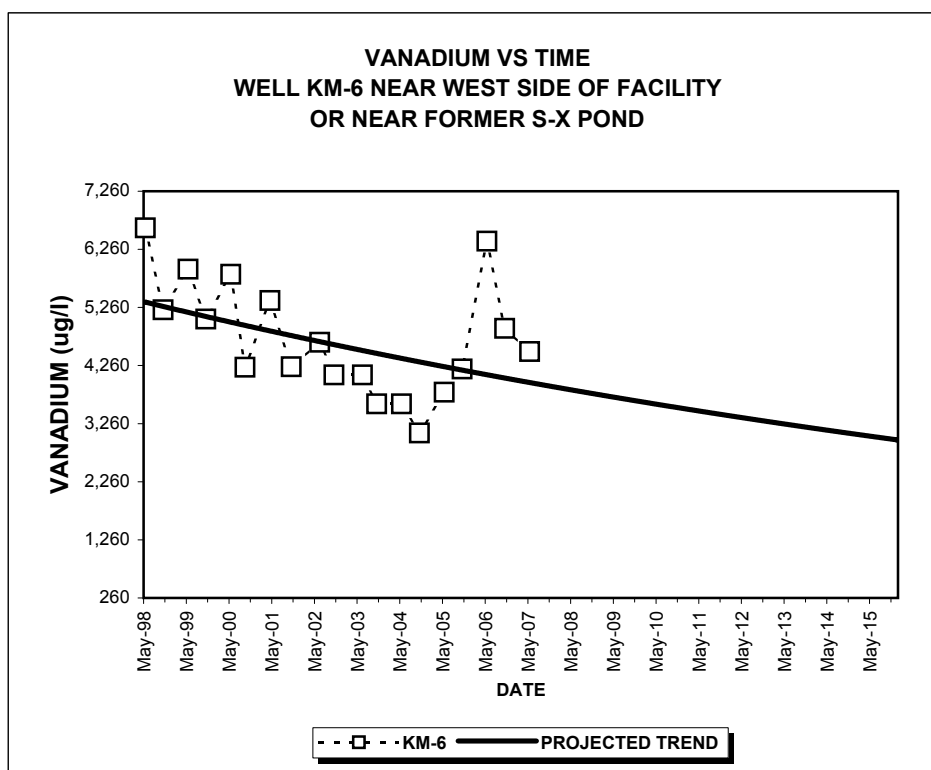
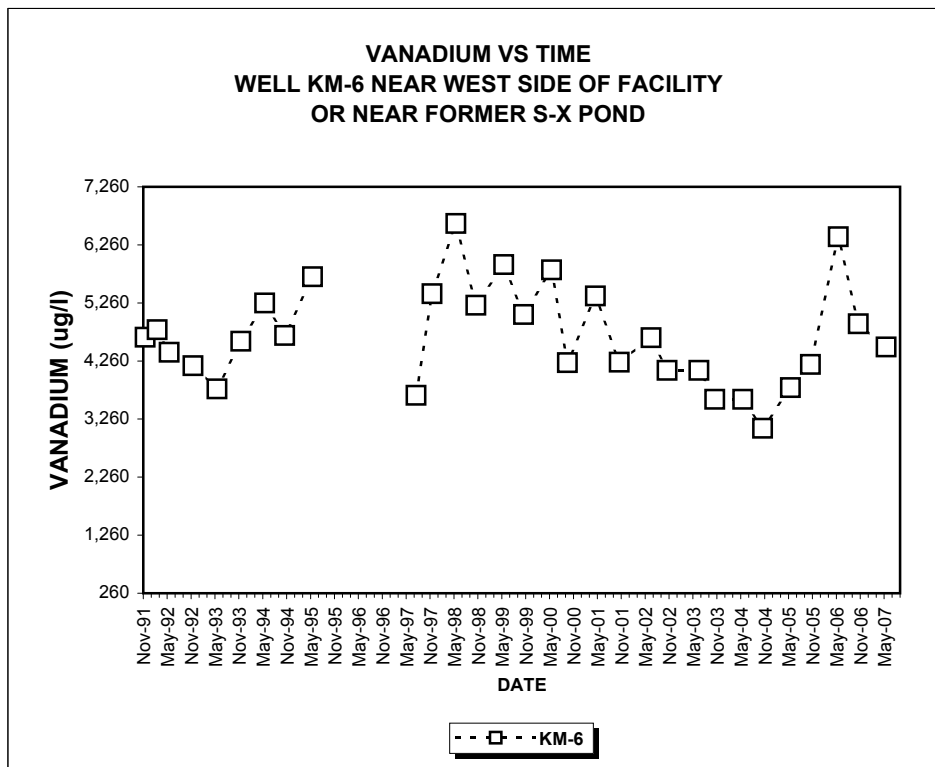
RBC FOR VANADIUM IS 260 UG/L

KM-5 IS A POC WELL

PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING LSE

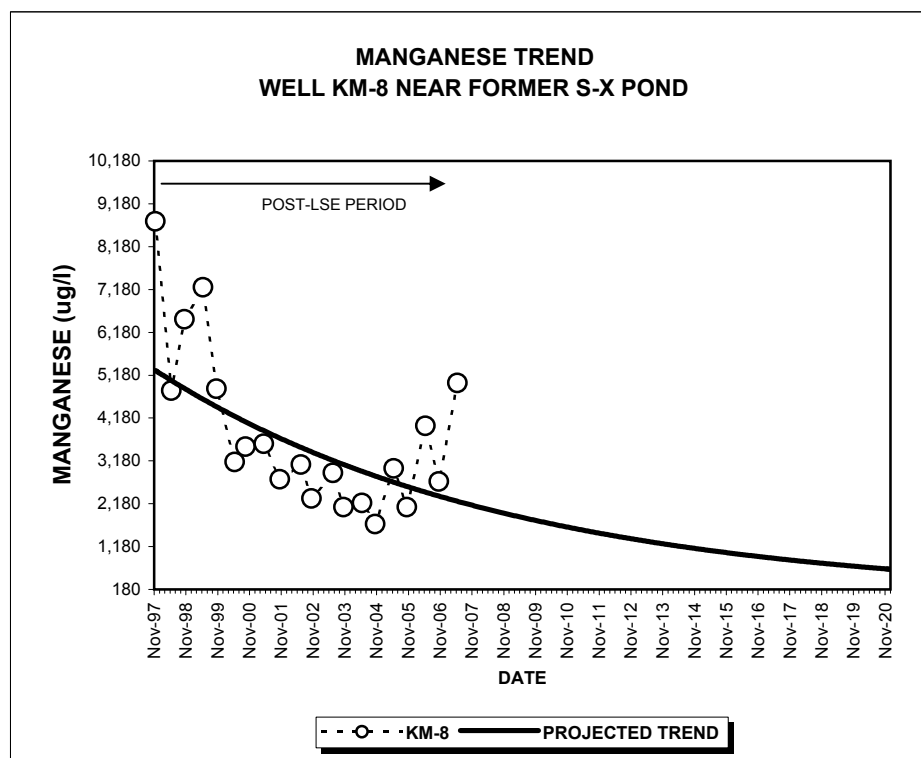
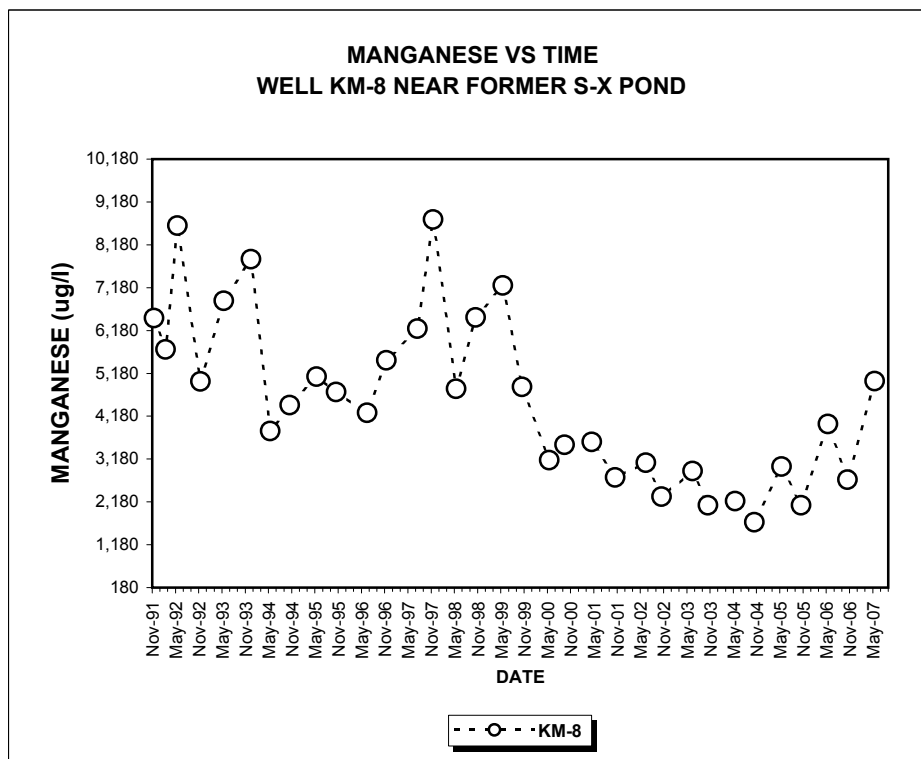
**COC CONCENTRATIONS
AND PROJECTED TRENDS VERSUS TIME**

RBC FOR MOLYBDENUM IS 260 UG/L

**COC CONCENTRATIONS
AND PROJECTED TRENDS VERSUS TIME**

RBC FOR VANADIUM IS 260 UG/L

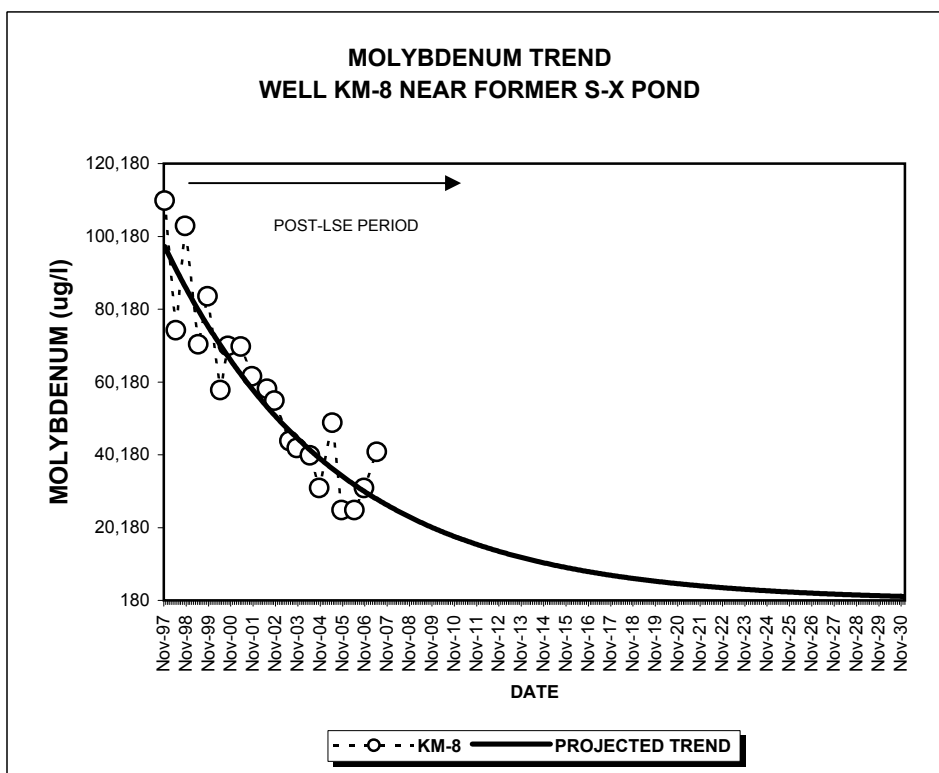
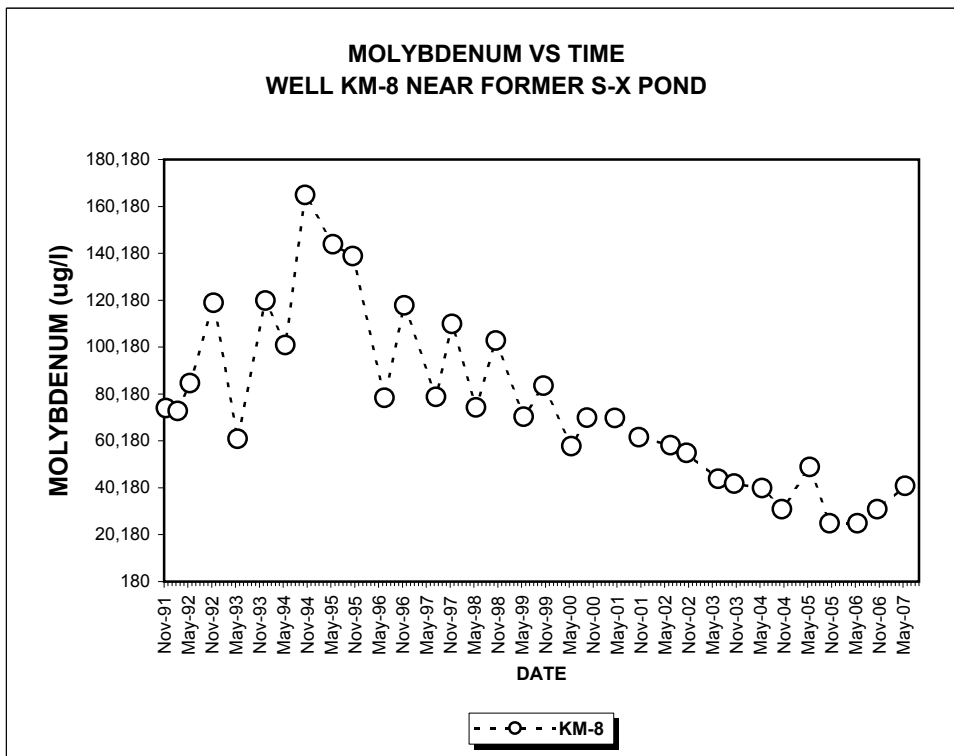
COC CONCENTRATION TRENDS WITH TIME AND PROJECTED TRENDS



RBC FOR MANGANESE IS 180 UG/L

KM-8 IS A POC WELL

PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING LSE AND RECLAMATION

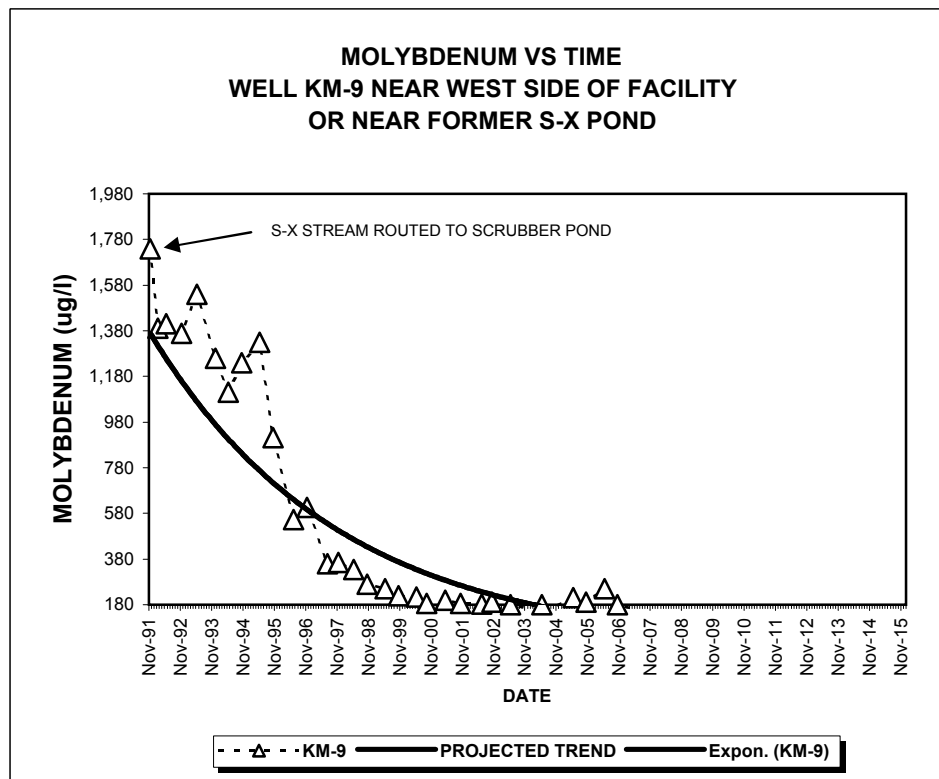
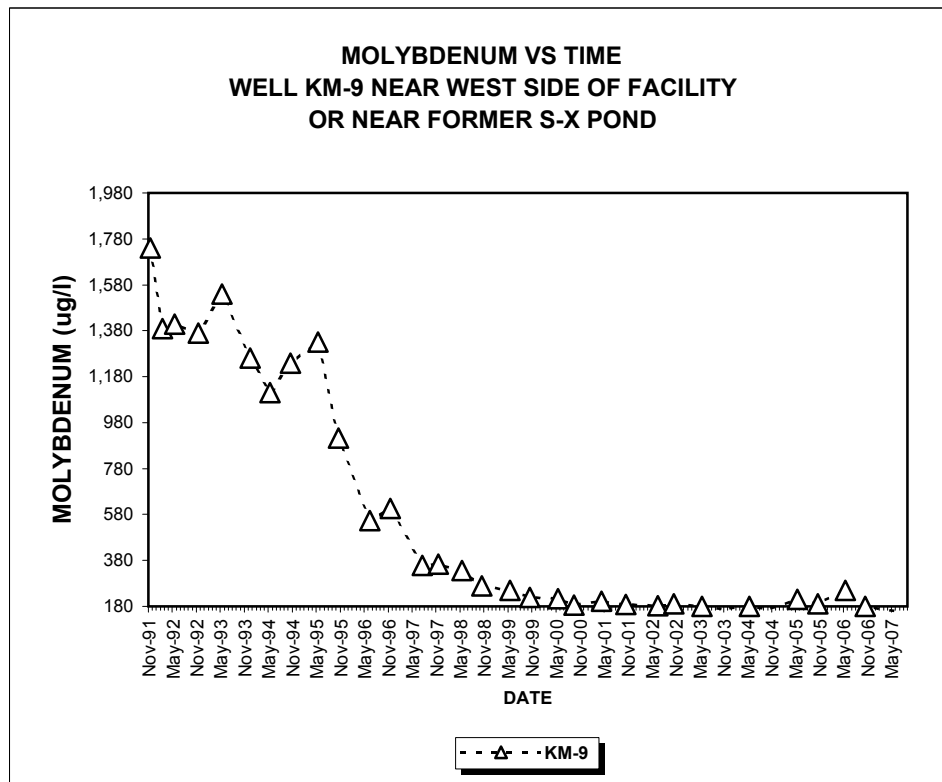
**COC CONCENTRATION TRENDS WITH TIME
AND PROJECTED TRENDS**

RBC FOR MOLYBDENUM IS 180 UG/L

KM-8 IS A POC WELL

PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING LSE AND RECLAMATION

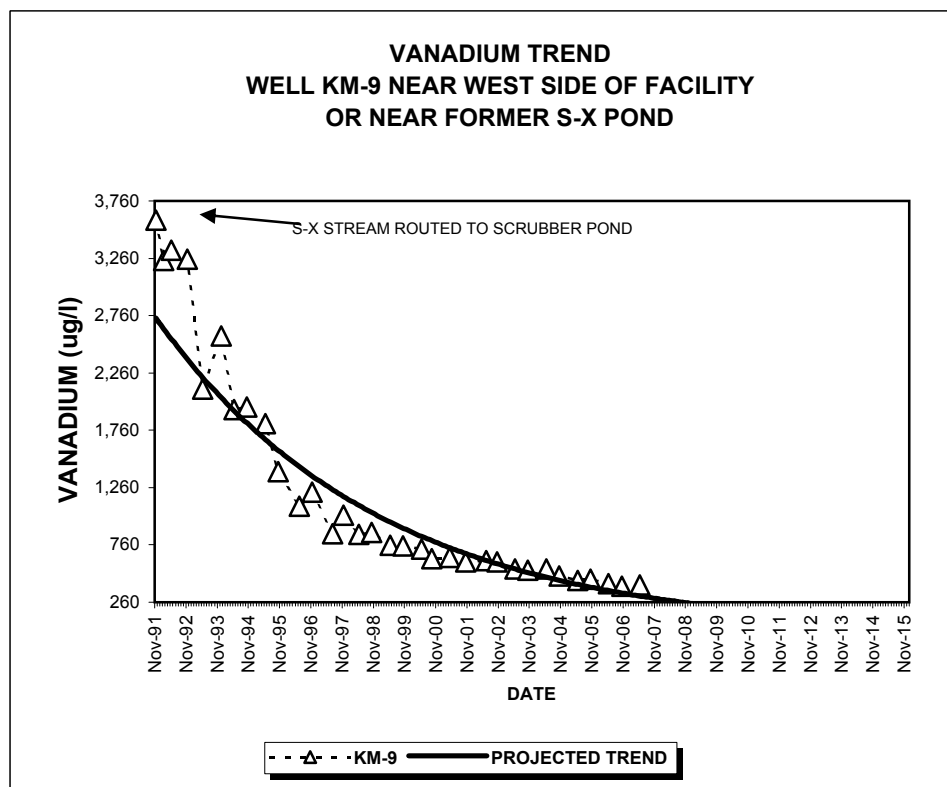
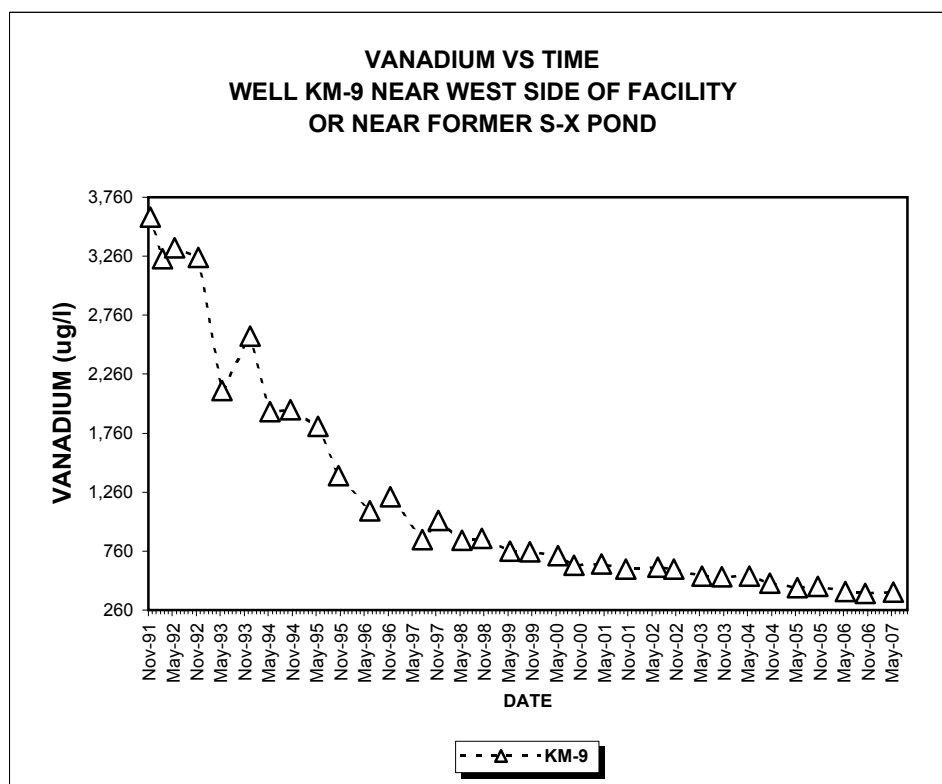
COC CONCENTRATION TRENDS WITH TIME AND PROJECTED TRENDS



RBC FOR MOLYBDENUM IS 180 UG/L

KM-9 IS A POC WELL

PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING REROUTING OF S-X STREAM

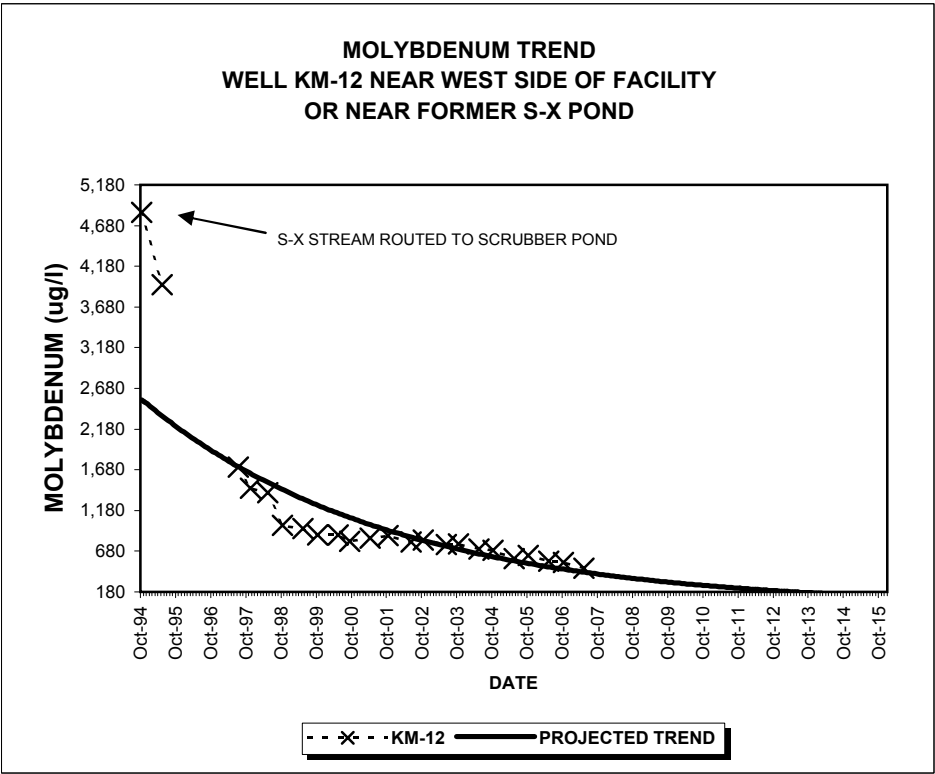
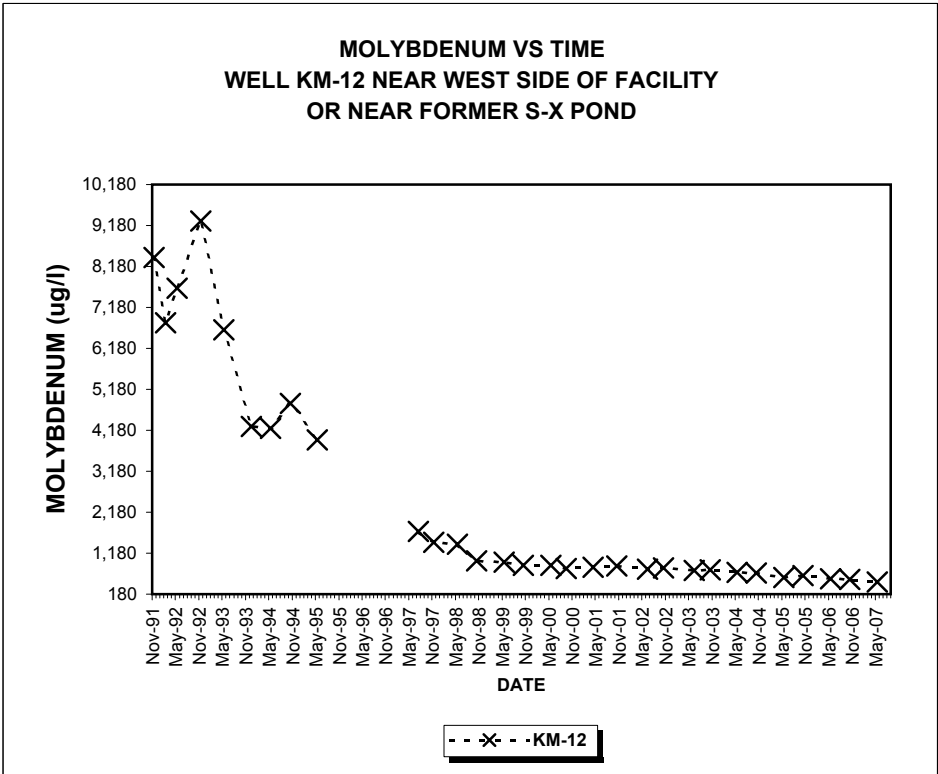
**COC CONCENTRATION TRENDS WITH TIME
AND PROJECTED TRENDS**

RBC FOR VANADIUM IS 260 UG/L

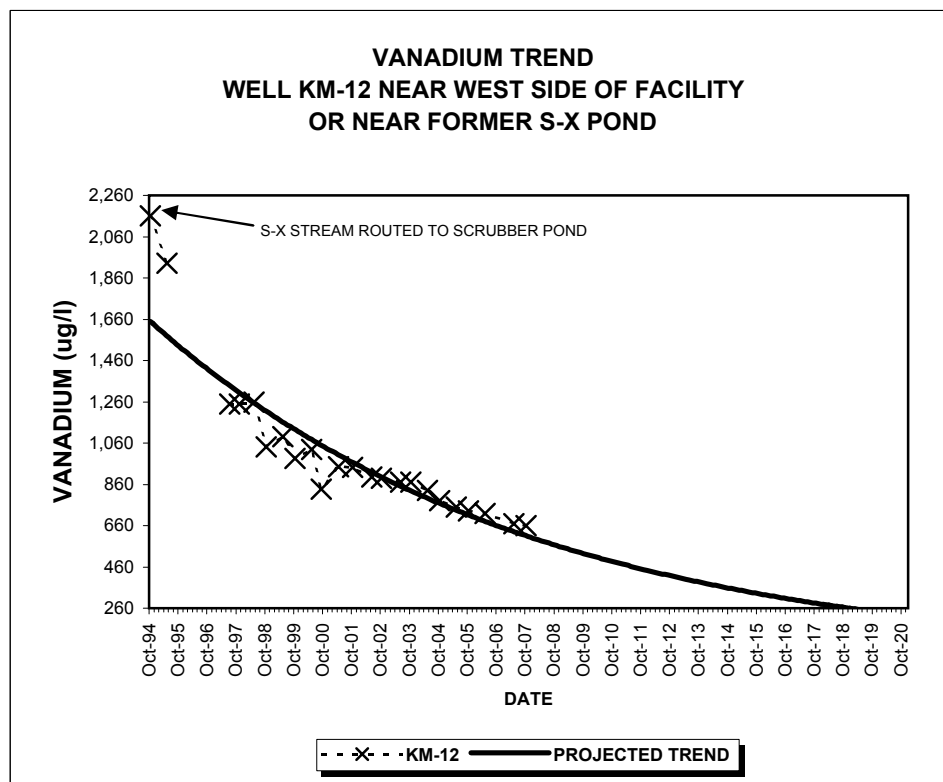
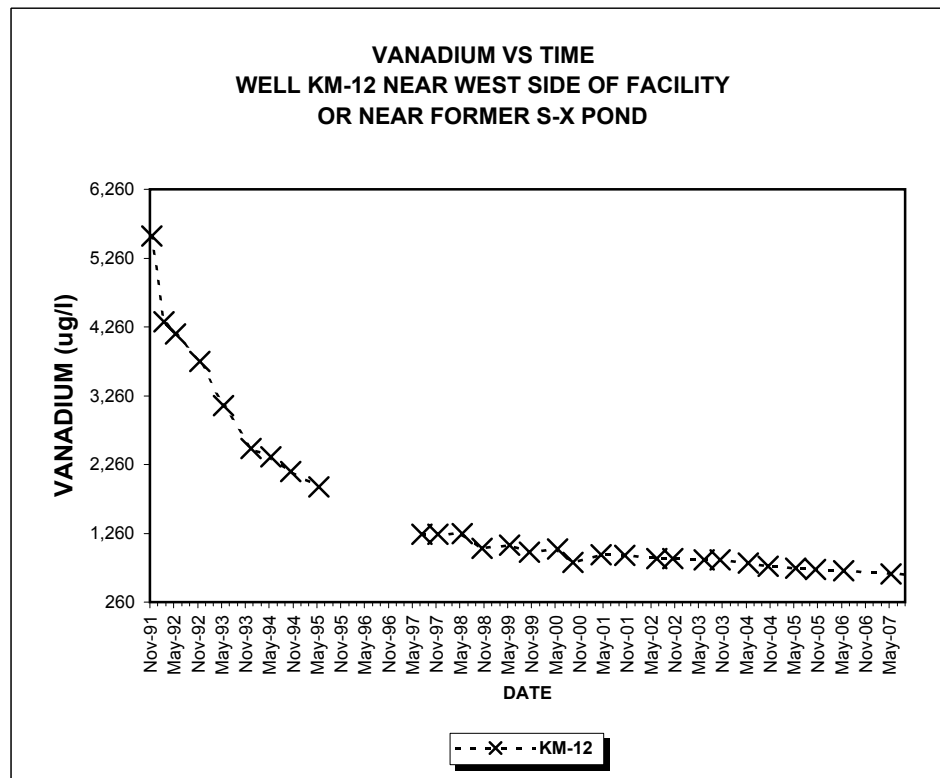
KM-9 IS A POC WELL

PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING REROUTING OF S-X STREAM

**COC CONCENTRATION TRENDS WITH TIME
AND PROJECTED TRENDS**



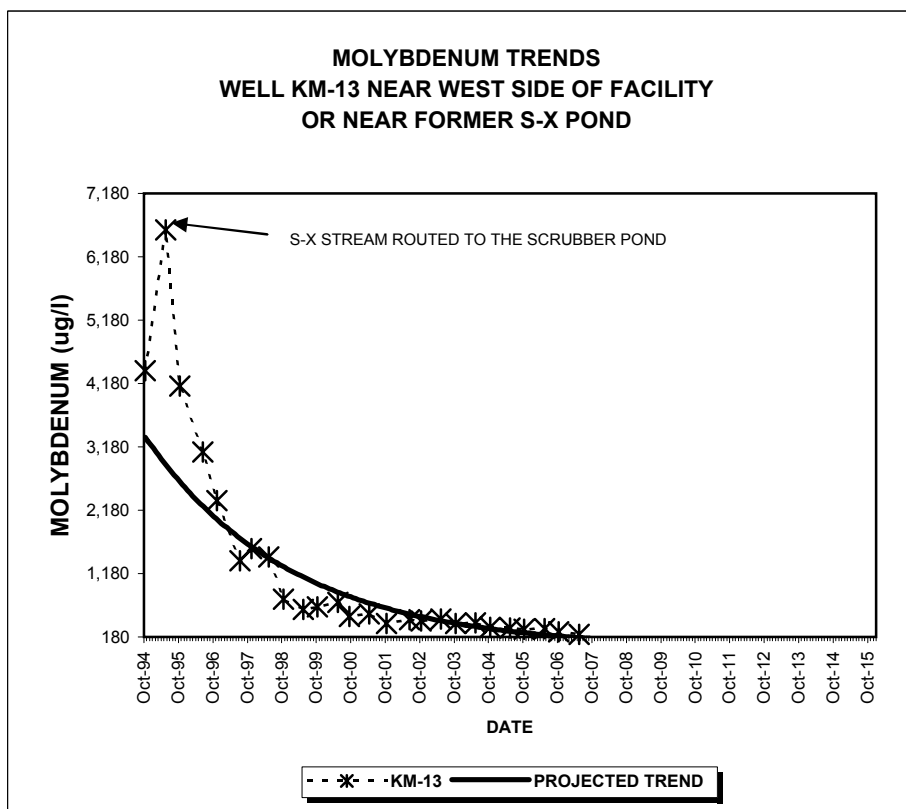
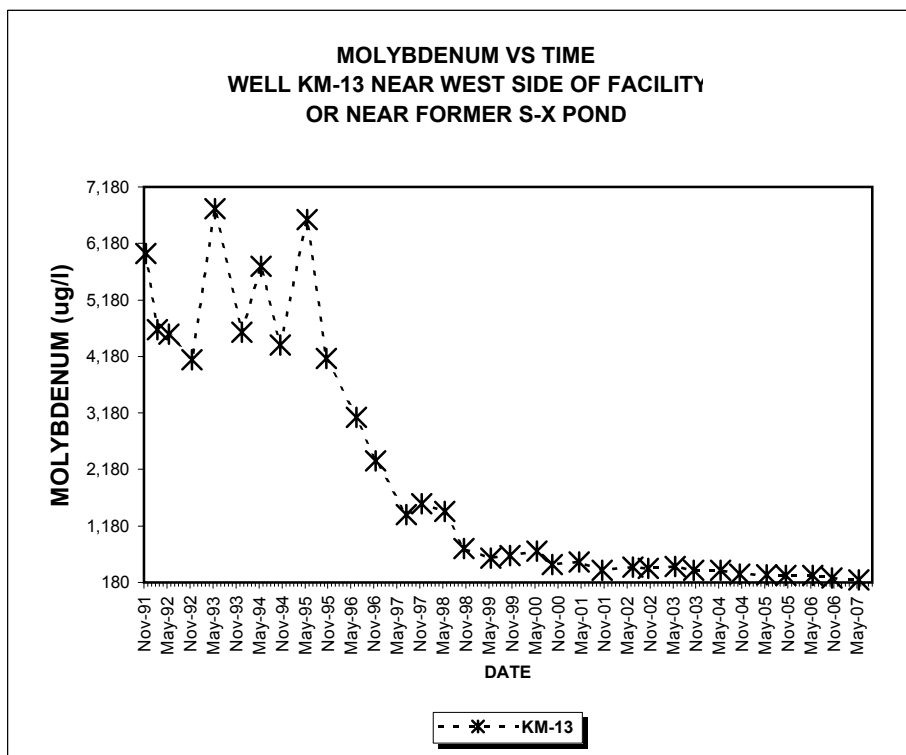
RBC FOR MOLYBDENUM IS 180 UG/L
KM-12 IS A POC WELL
PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING REROUTING OF THE S-X STREAM

**COC CONCENTRATION TRENDS WITH TIME
AND PROJECTED TRENDS**

RBC FOR VANADIUM IS 260 UG/L

KM-12 IS A POC WELL

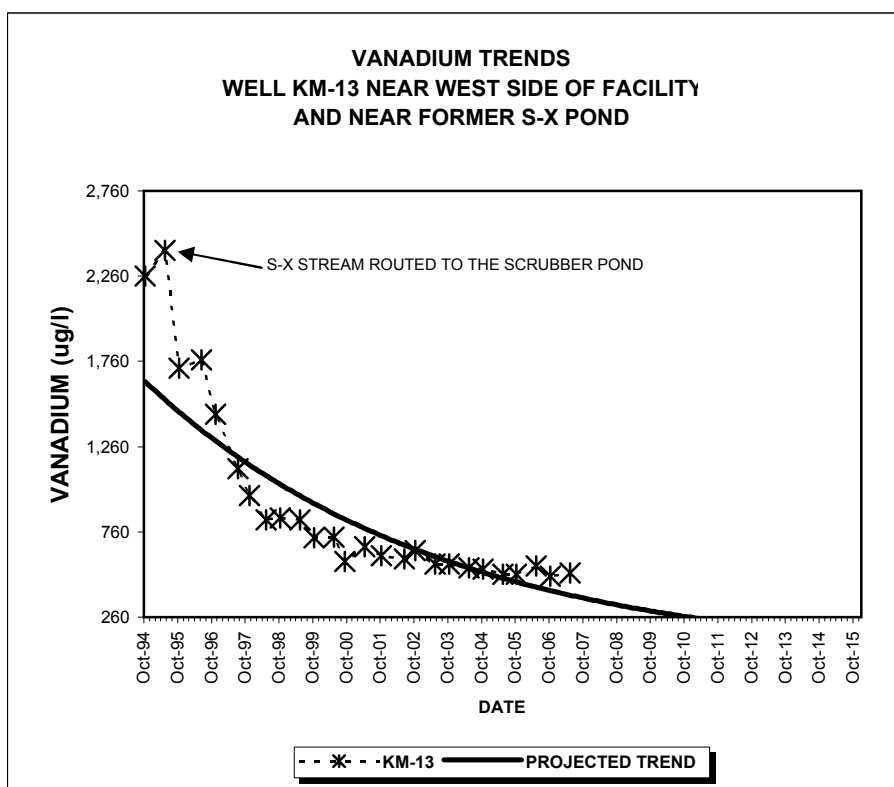
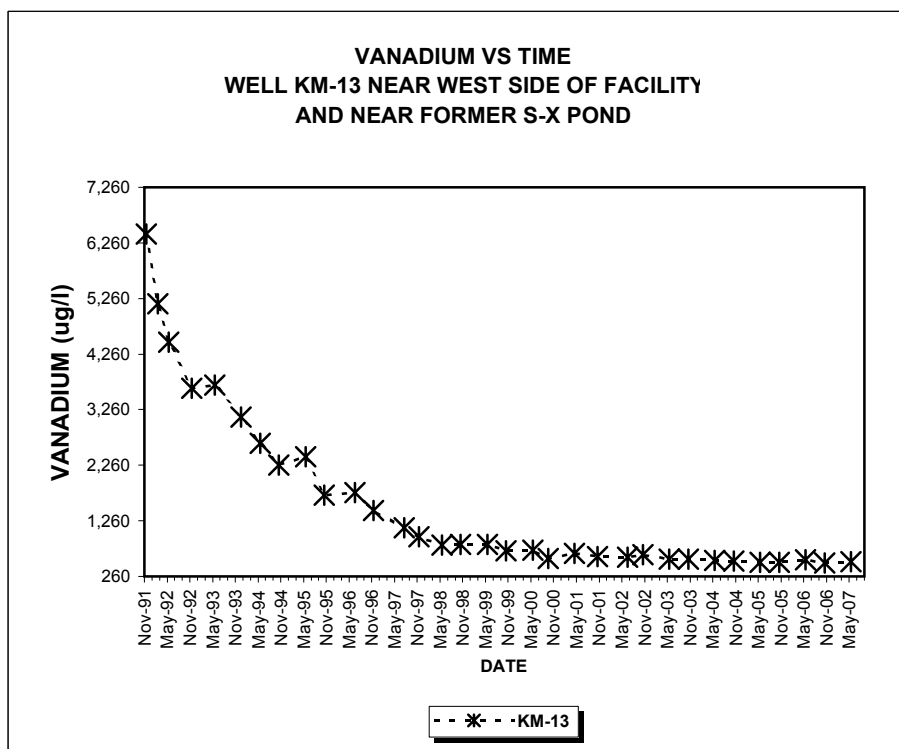
PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING REROUTING OF THE S-X STREAM

**COC CONCENTRATION TRENDS WITH TIME
AND PROJECTED TRENDS**

RBC FOR MOLYBDENUM IS 180 UG/L

KM-13 IS A POC WELL

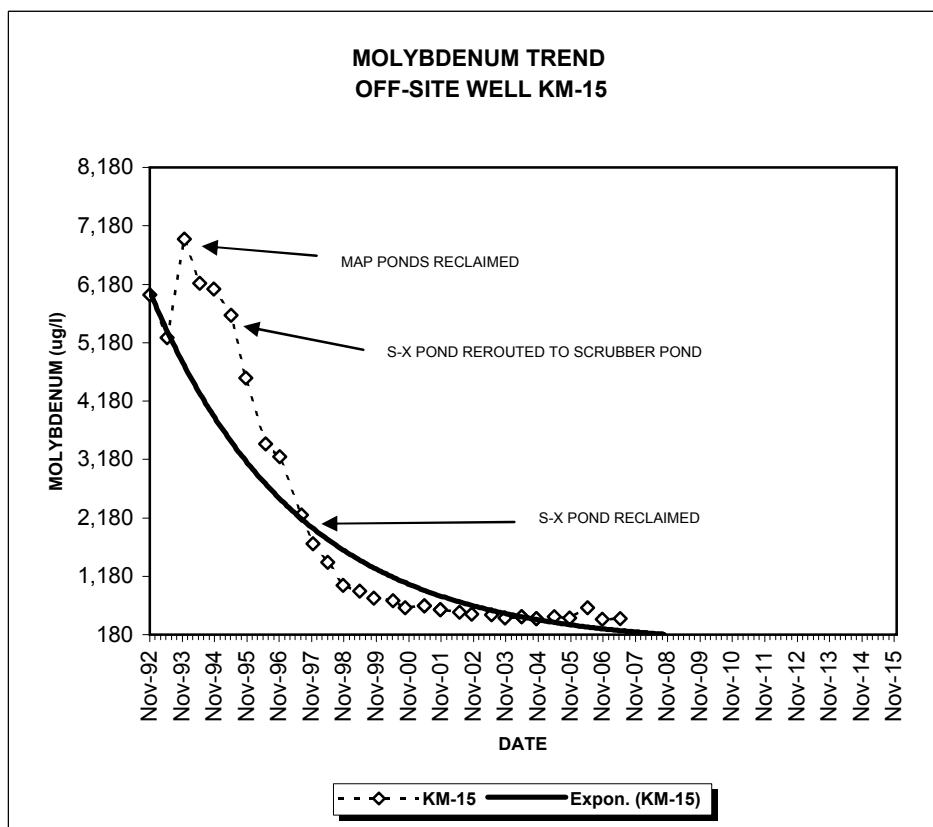
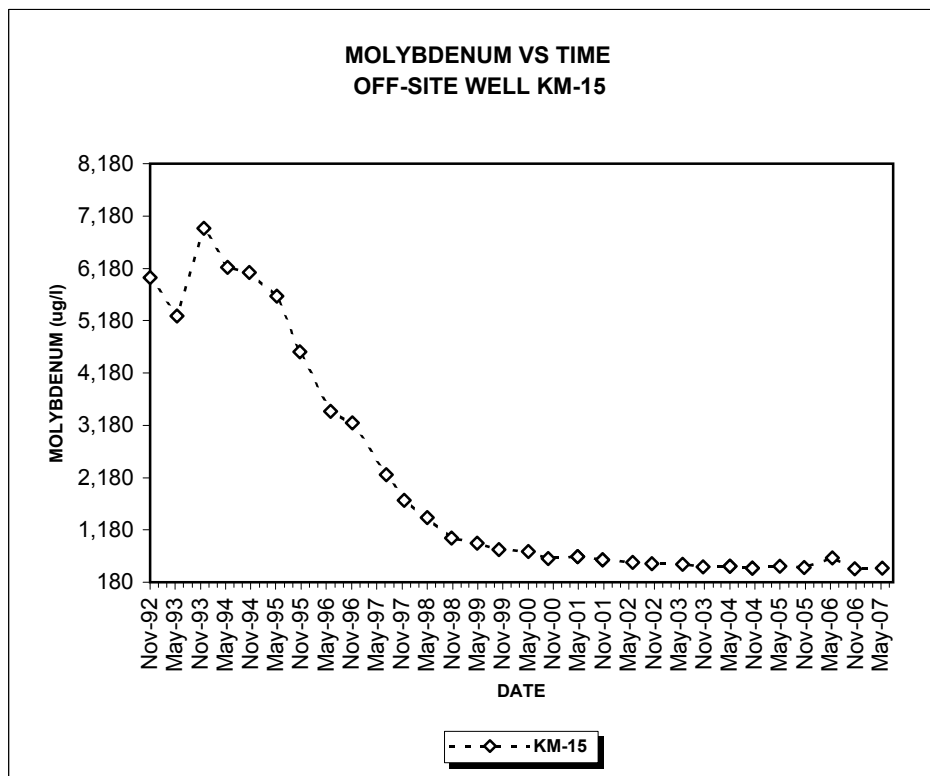
PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING REROUTING OF THE S-X STREAM

**COC CONCENTRATION TRENDS WITH TIME
AND PROJECTED TRENDS**

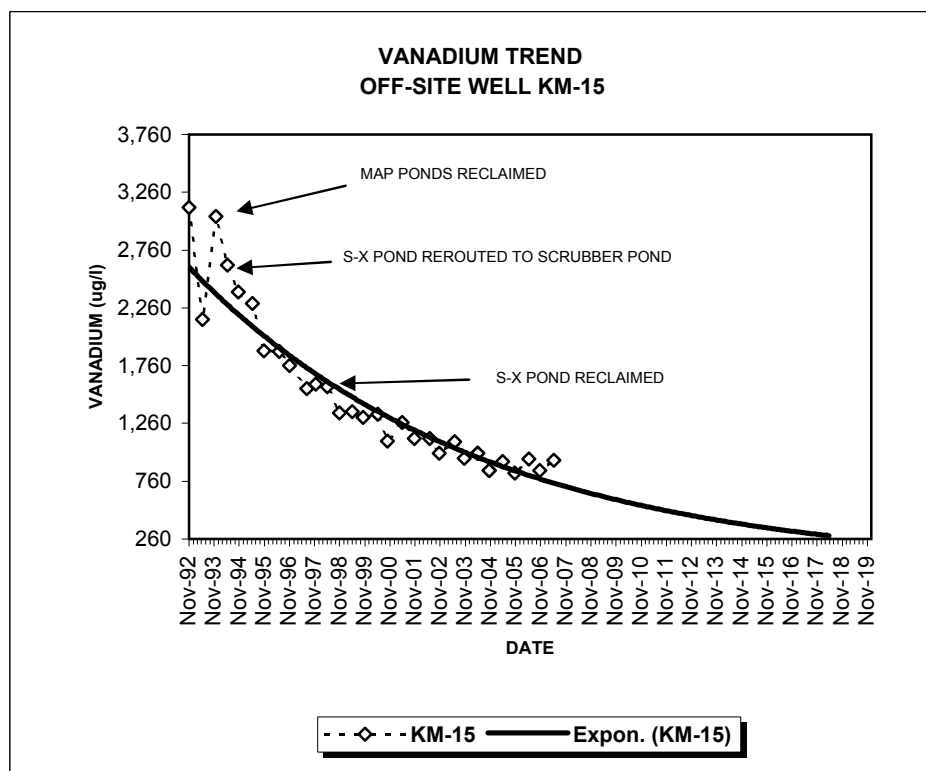
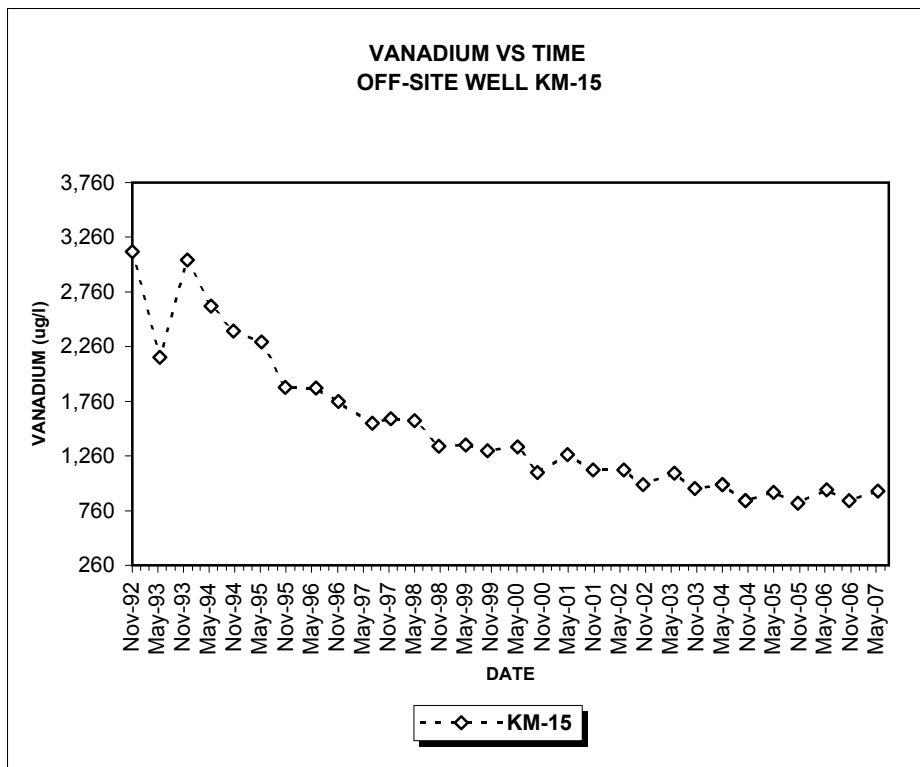
RBC FOR VANADIUM IS 260 UG/L

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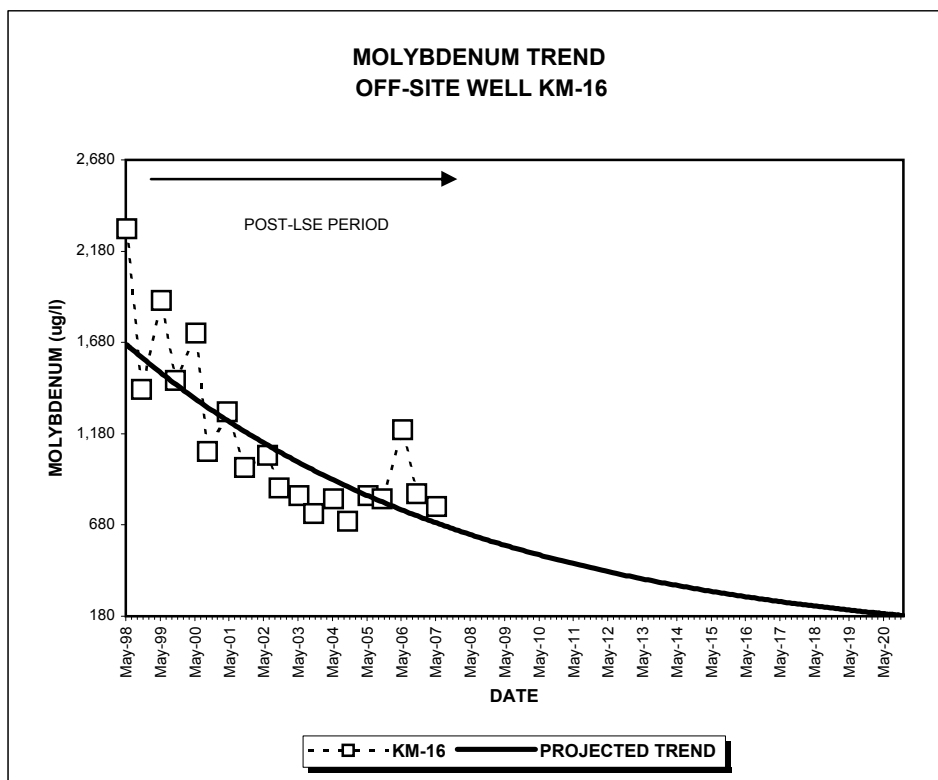
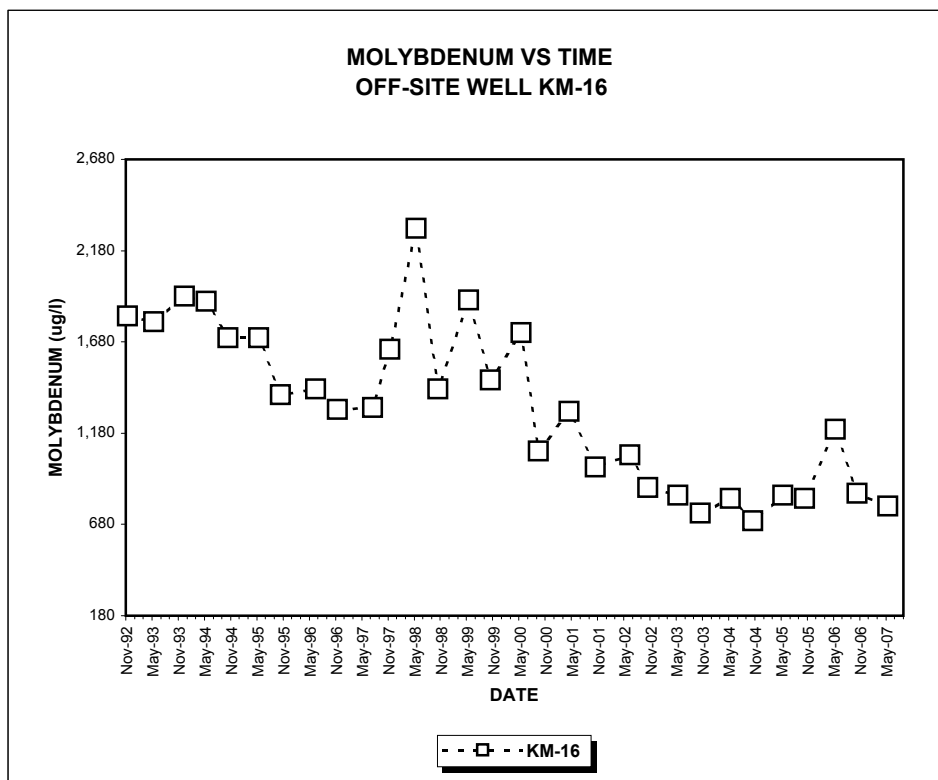
PROJECTED TRENDS BASED ON OBSERVATIONS FOLLOWING REROUTING OF THE S-X STREAM

**COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS**

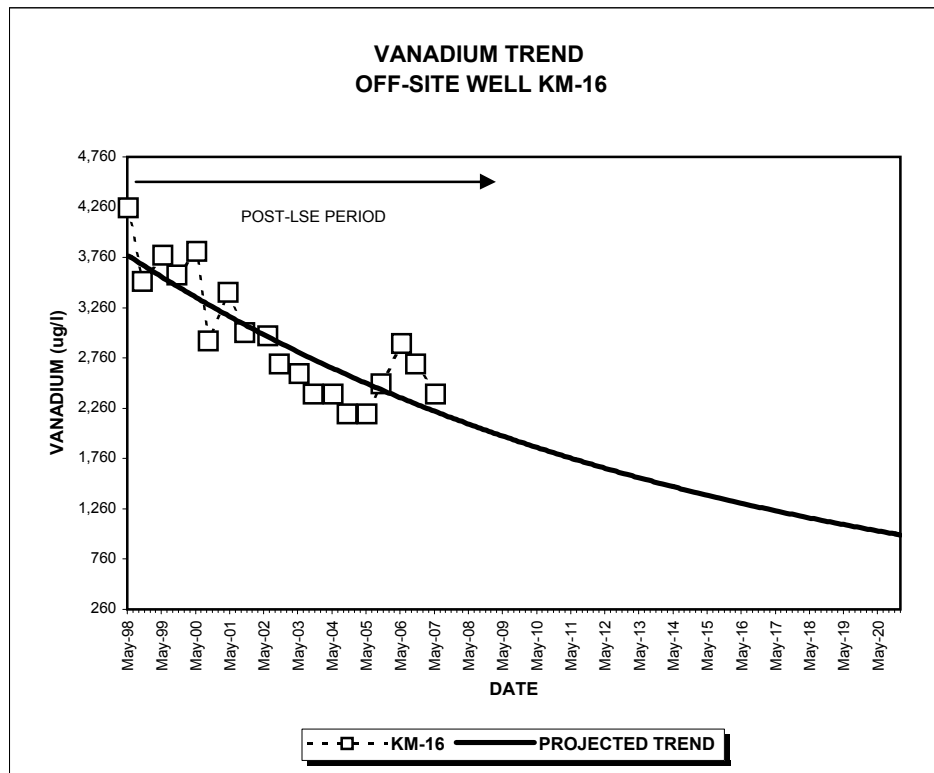
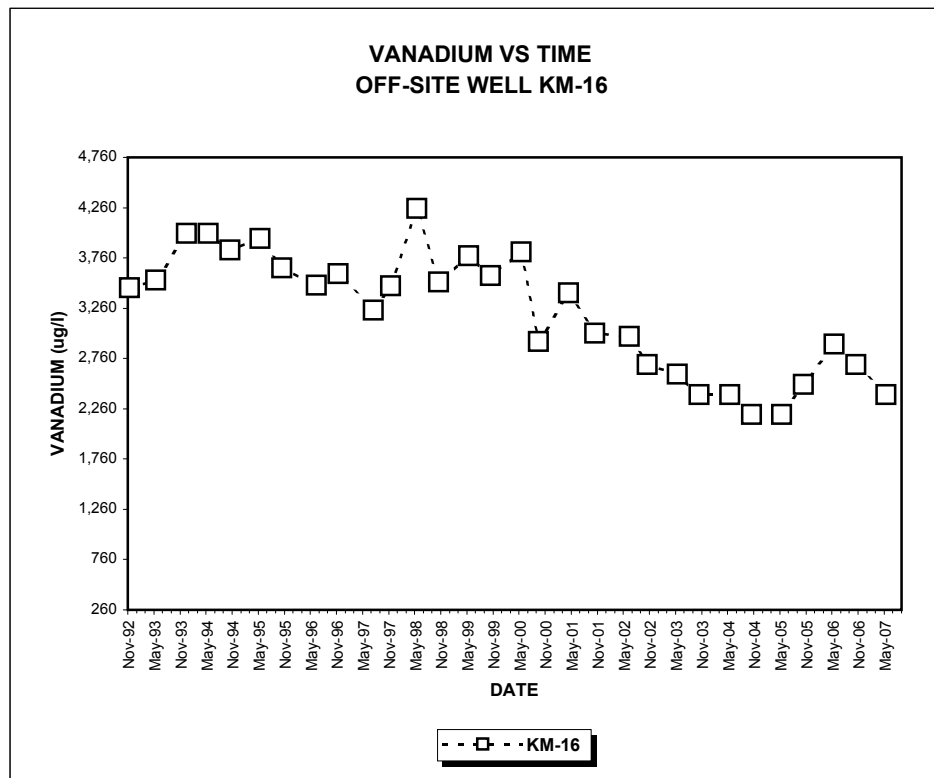
RBC FOR MOLYBDENUM IS 180 UG/L

**COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS**

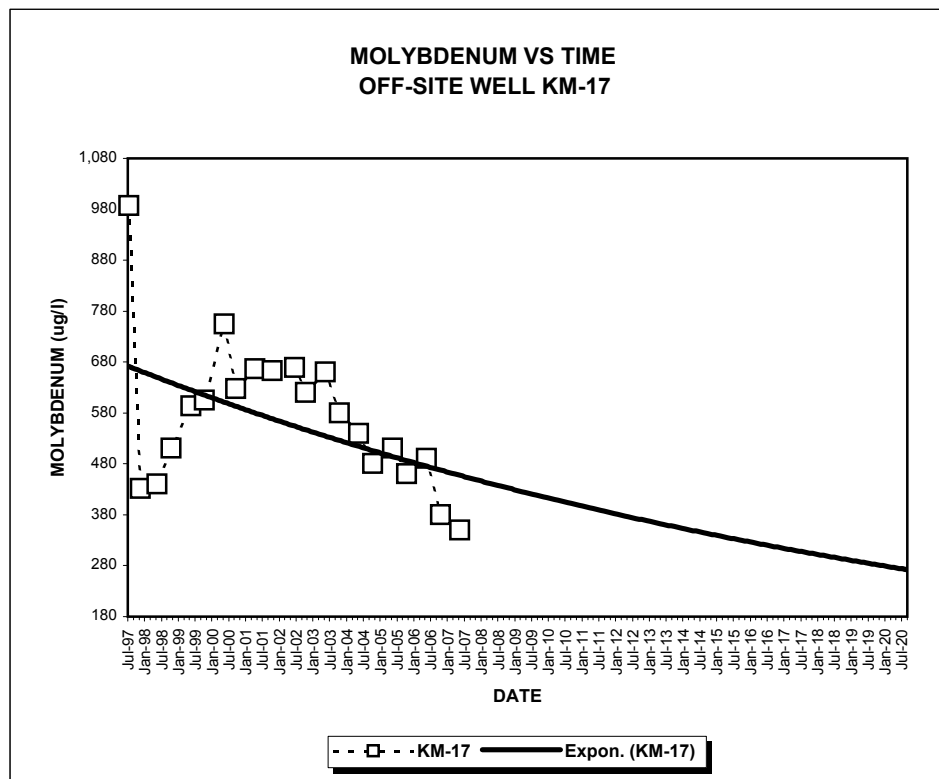
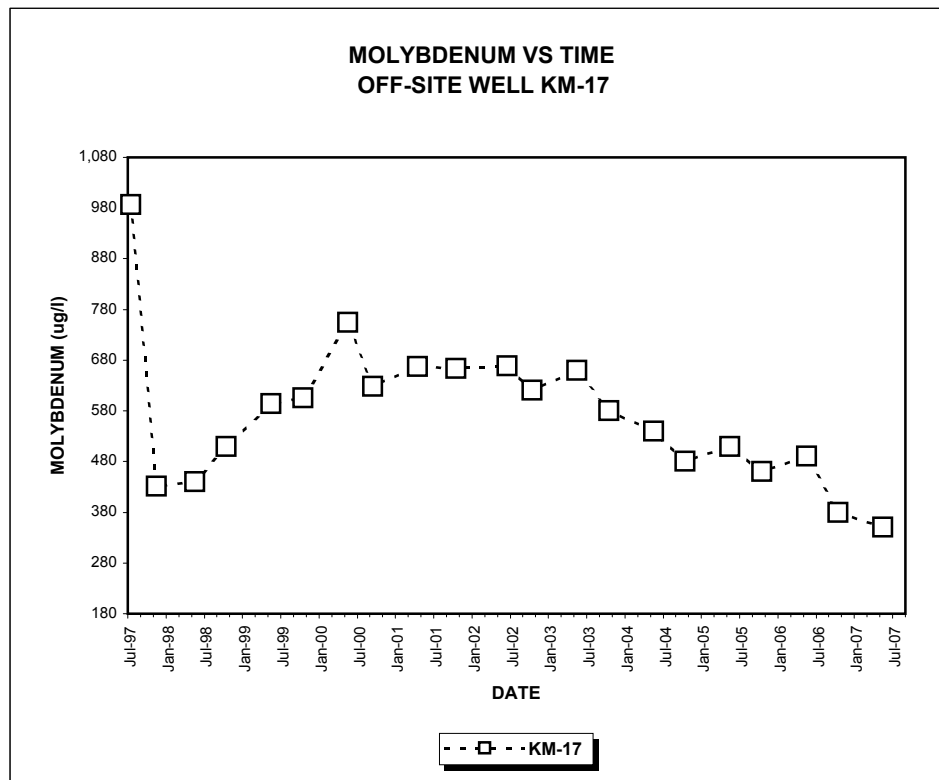
RBC FOR VANADIUM IS 260 UG/L

**COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS**

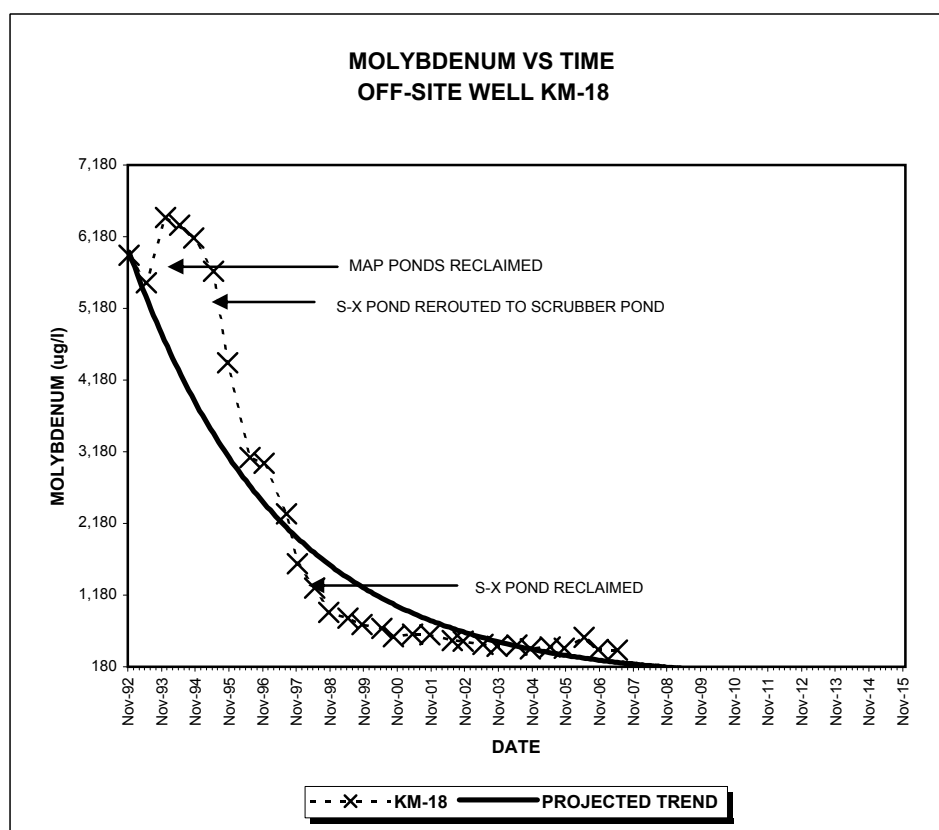
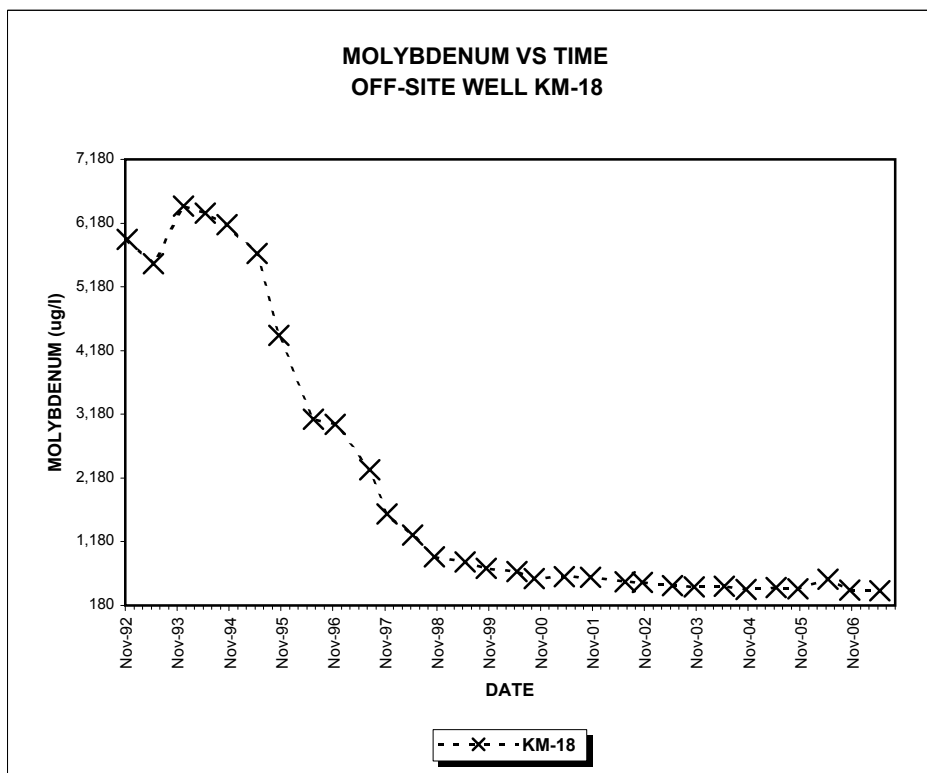
RBC FOR MOLYBDENUM IS 180 UG/L
PROJECTED TREND BASED ON OBSERVATIONS FOLLOWING
COMPLETION OF LSE AND RECLAMATION

**COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS**

RBC FOR VANADIUM IS 260 UG/L
PROJECTED TREND BASED ON OBSERVATIONS FOLLOWING
COMPLETION OF LSE AND RECLAMATION

**COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS**

RBC FOR MOLYBDENUM IS 180 UG/L
PROJECTED TREND BASED ON OBSERVATIONS FOLLOWING
COMPLETION OF LSE AND RECLAMATION

**COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS**

**COC CONCENTRATIONS WITH TIME
AND PROJECTED TRENDS**